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THE 1,000-TON BARGE CANAL BILL passed the New York Senate on March 24 by a vote of 32 to 14, after a debate lasting six hours. The Lewis resolution, for the appointment of a commission to ascertain the possibility of a deep waterway, in co-operation with the United States, was defeated by a vote of 31 to 12. The 14 votes cast against the bill were cast by Republicans, and those voting for the bill included 11 Republicans and 21 Democrats. As noted in our issue of March 19, the bill requires approval by popular vote at the next election before it can become a law.

A RAILROAD BRIDGE over the East River at Ward's Island, New York city, will be built by the Pennsylvania Railroad, according to statements made by President A. J. Cassatt while on the witness stand in New York city on March 24. The bridge will be designed especially for the carriage of through freight from the West to New England. The freight cars will be transferred in car floats from Greenville, N. J., across New York Bay to Bay Ridge, L. I., and will then be moved on the tracks of the Long Island R. R. to the Ward's Island bridge. On the other side of the bridge connection will be made with the New York, New Haven & Hartford R. R.

A HUDSON RIVER TUNNEL for electric cars is planned to run from Exchange Place in Jersey City, N. J., to Cortlandt St. in New York city. Various financial interests are reported as being the backers of the project, and the engineers are stated to be Jacobs & Davies, of New York city. About all that is definitely known is that a company, which it is stated is to build and operate a third tunnel under the Hudson River, has been incorporated at Albany, N. Y., as the Hudson & Manhattan R. R. Co. Its capitalization is $3,000,000. According to its charter the company is to construct a tunnel railroad approximately one mile long, from Broadway and Cortlandt St., in New York, to the boundary line of New Jersey, there to connect with the railroad of a New Jersey corporation extending westerly to a point in Jersey City. The directors named are George P. Bester, of Bloomfield, N. J.; Howard Slade and William H. Siegl, of New York city; Clifton Graham, of Flushing; Robert Maroney, Charles H. Aron, James Davidson and A. F. Richter, of Brooklyn, and A. B. Proctor, Jr., of Boonton, N. J.

AN INCREASE OF THE CIVIL ENGINEER CORPS of the Navy is provided for by the Navy bill, which, by President Roosevelt's signature, became a law in the last hours of the 57th Congress. This bill authorizes an increase in the Civil Engineer Corps of the Navy to a total of 40, comprising 28 full civil engineers and twelve assistant civil engineers, three of the latter to be appointed each year, until the maximum number is reached. There are at present two vacancies in the grade of full civil engineer. Another examination will be held in the near future to fill these vacancies, and also to secure three assistant civil engineers who can be appointed this year. A second examination will probably be held in November or December of this year, to secure the men who may be appointed in 1904. After that there will be annual examinations. The age limits in the examinations for assistant civil engineer will probably be from 23 to 28 years, and the requirements as to experience and length of responsible charge of work much reduced. The general standard and scope of the examination will also be modified. As the result of the operation of the above law, and of retirements in the corps, there will be two vacancies in the grade of full civil engineer and 14 in the grade of assistant civil engineer to be filled by competitive examinations in the next three years. It will be well for young engineers to keep their eyes on these examinations.

THE ANTHRACITE STRIKE COMMISSION has awarded a 9-hour day to the "company men" and a 10% increase in rates paid contract miners. It has recommended the appointment of a Board of Conciliation consisting of three men selected by the miners and three selected by the mine operators. The two principal demands of the miners have been ignored, namely, (1) recognition of the union, and (2) payment for coal by weight. The rulings of the Commission are to be binding for three years.

THE MOST SERIOUS RAILWAY ACCIDENT of the week was a head collision on the Delaware, Lackawanna & Western R. R. on March 18 near Washington, N. J., in which the engineers of both trains were killed. One of the trains had taken a siding to allow the other to pass, but had not entirely cleared the main track in doing so. No great damage was done to either the colliding engines or to the trains.

A STEAMBOAT COLLISION on Long Island Sound, near Plum Island, on March 20, resulted in the death of six persons and considerable damage to the vessels. The colliding steamers were the "Plymouth" and "Taunton," both of the Fall River Line, and the accident was due to fog. Both vessels were able to reach port unaided.

A FLYWHEEL BURST, wrecking a 700-HP. engine and generator at the Los Angeles (Cal.) Traction Co.'s power house, March 16. The property loss was $51,000, but no one was injured.

A BOILER EXPLODED, March 21, at the roundhouse of the New York, New Haven & Hartford R. R., at Taunton, Mass. A fireman was killed and three other men injured by flying debris. The boiler is said to have been an old locomotive boiler which was used for heating purposes.

STRIKING AN UNEXPLODED DYNAMITE charge with a pick caused an explosion in a foundation excavation at Gardner, Mass., March 21. The explosion destroyed the eye of one of the workmen and otherwise seriously injured him.

THE LARGEST OIL TANK STEAMER ever constructed has been launched from the yards of Scott & Co., at Greenock, Scotland, for the Anglo-American Oil Co., Ltd. She has a gross tonnage of 11,000, and a carrying capacity of 12,500 tons of oil, her length being 531 ft., beam 63.6 ft., and depth 42 ft. The name of this steamer will be the "Narragansett." The vessel is equipped with four oil pumps capable of discharging 900 tons of oil per hour.

THE EAST RIVER TUNNEL to be built as part of the New York Rapid Transit Ry. was begun on March 24 by Andrew Onderdonk, the contractor. The work started was the sinking of a shaft on the Brooklyn side in Joralemon St., near Henry St.

PUBLIC WATER-WORKS IN CONNECTICUT draw their supplies from 117 drainage areas, with an aggregate area of 577 sq. miles, or over one-ninth of the total area of the state. Of the total area named 3.2 sq. miles are in Massachusetts and 18.8 in New York, but to offset this the city of New York has 20.8 miles of its Croton drainage area in Connecticut. The last annual report of the Connecticut Sewerage Commission contains a tabular list and a map showing these various gathering grounds and their respective areas; the same map, and other tables, show the areas (cities, towns or boroughs) supplied with water and having, and also those not having, sewerage systems. Mr. Robert Cairns, M. Am. Soc. C. E., Waterbury, Conn., is a member of the commission in question.

THE HAZEN-WILLIAMS HYDRAULIC SLIDE RULE, recently perfected by Mr. Allen Hazen, M. Am. Soc. C. E., 220 Broadway, New York city, and Prof. Gardner S. Williams, M. Am. Soc. C. E., of Cornell University, Ithaca, N. Y., resembles in general form the ordinary slide rule, and is designed to solve various problems involving diameter, hydraulic radius, slope of conduit, velocity, and quantity or discharge. On the reverse side of the rule are a number of handy tables, including velocities and discharge with C = 100 for slopes of 0.1, 1.0, and 10, and diameters 2 to 60 ins.; feet of pipe of various diameters in which friction equals velocity head, for C = 100 and for C = 130; approximate values of C for different classes of conduits; and factors for a number of the conversions which the hydraulic engineer is most commonly required to make, such as gallons to cubic feet and to pounds, and metric to English weights and measures. One of the edges of the rule has a scale in inches and the other has a metric scale.

BIDS FOR WOOD BLOCK PAVEMENT in Brooklyn Borough, New York city, are to be received on April 1 by J. Edw. Swanstrom, Borough President. There will be about 16,000 sq. yds. of pavement, divided between six streets. Most of the pavement will be composed of blocks 4 ins. deep, and all of it will be laid on a concrete foundation.

A NEW RAILWAY IN SOUTH AFRICA is to be built by the Lisbon Government from Laurenco Marquez to Johannesburg, 337 miles, passing through the Swaziland coal fields.

STEAM VESSELS added to the registered mercantile marine of Great Britain during 1902 aggregated 1,192,389 tons gross. The addition of sailing vessels amounted to 57,120 tons. Of these totals about 92.5% were new vessels built in Great Britain. The total deductions from the register were 404,641 tons of steam tonnage and 101,514 tons of sail tonnage. We take the above figures from "The Engineer" (London).

NERNST LAMPS are coming into extensive use for lighting factories and industrial plants, where their greater economy in the use of current and their excellent light offsets the labor required for their care. The town of Rouses Point, N. Y., has recently adopted 3-glower Nernst lamps for street lighting.

THE STEEL FLOATING DRY-DOCK for the U. S. Naval Station at Cavite, Philippine Islands, for which bids were received on March 14, is to be of 16,000 tons capacity. The general requirements of construction for this dock were as follows:

The dock in general shall be so designed and arranged as to be readily self-docking without the aid of divers or auxiliary constructions. It shall be self-contained as to operating machinery, and capable of being towed from place to place safely without auxiliary bracing. It shall be of the general type composed of water-tight side walls and body, or pontoons, with a general-shaped cross-section, and divided into sufficient water-tight compartments to give great stability, there being not less than six transversely. Simplicity and certainty of operation and freedom from possible disablement in all operations should be given careful consideration by designers.

The dock shall be not less than 500 ft. long over all, none of which length shall consist of bracketed platforms without lifting power.

The dock shall have a clear width between fenders of not less than 100 ft.

The decks of side walls shall have not less than 8 ft. of clear height above the water, with 30 ft. draft over 4-ft. keel blocks.

The dock shall have a lifting capacity of not less than 16,000 gross tons, uniformly distributed over its entire length, with the main deck not less than 2 ft. above the water, and with not less than 1 ft. of water in the compartments.

The dock shall be operated by steam power, and shall be fitted with all the necessary boilers, engines, pumps, feed water heaters, steam separators, and other accessories desirable to make a first-class self-contained plant.

There shall be not less than 600 nominal horse-power of boilers and engines suitably distributed to give the best results. Simplicity and certainty of action and freedom from possible breakdown in operation are to be given the first consideration. Engines of a type and style which will produce the least vibration in the side walls are desired.

A NEW STEEL CONVERTER invented by Edwin C. Wells is in use at the works of the Uniform Steel Co., Rahway, N. J., for making steel castings. As described in the "Iron Age" of March 19, the converter is of small size and produces very hot metal, making it particularly suitable for foundry use.

STONE ARCH BRIDGE ON THE CHICAGO, MILWAUKEE & ST. PAUL RY. AT WATERTOWN, WIS.

The work of double tracking the La Crosse Division of the Chicago, Milwaukee & St. Paul Ry. includes the construction of a four-span, double-track, stone arch bridge over the Rock River at Watertown, Wis. This bridge is now being built, and will take the place of a single track iron bridge with four deck truss spans, built in 1884. The line is straight and level at this point. Each arch will have a span of 64 ft., a rise of 16 ft. 6 ins., and a radius of 39 ft. 3⅜-ins. The bridge will be 30 ft. wide over the coping courses, which will be level with the tops of the ties. The tracks are spaced 13 ft. c. to c. The general design and details of the structure are clearly shown in Fig. 1.

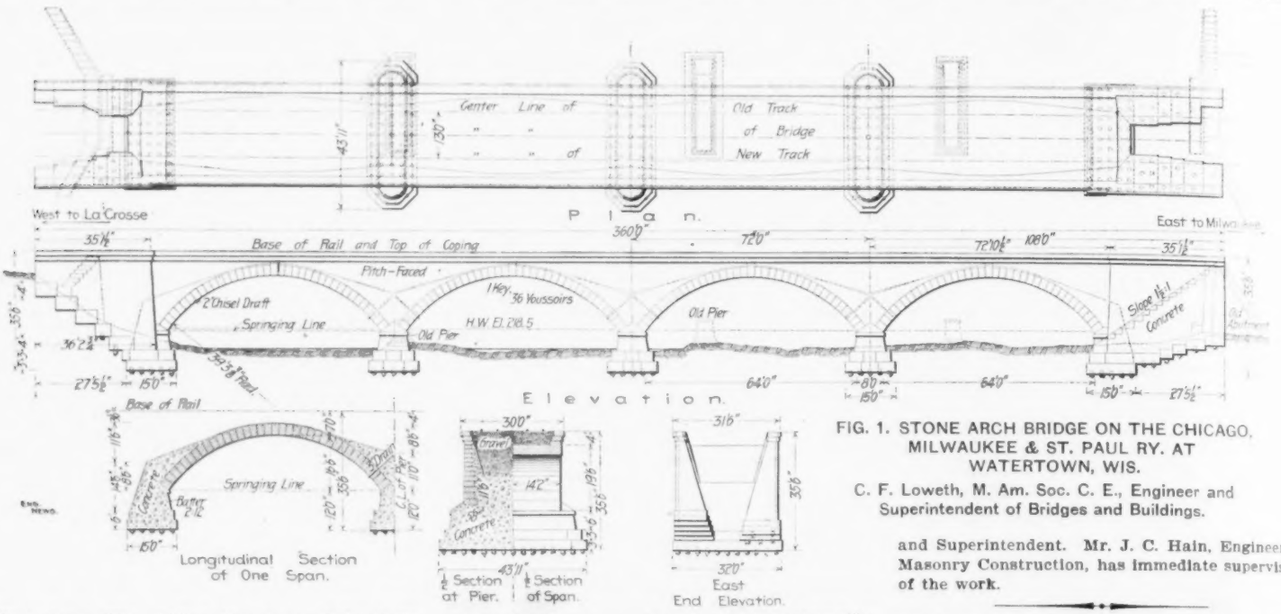


FIG. 1. STONE ARCH BRIDGE ON THE CHICAGO, MILWAUKEE & ST. PAUL RY. AT WATERTOWN, WIS.

C. F. Loweth, M. Am. Soc. C. E., Engineer and Superintendent of Bridges and Buildings.

The foundations are of oak piles driven to refusal into a very hard stratum of gravel and clay. Concrete will be used for the piers and for the abutments below the slope line of the embankment; also for spandrel filling and for the backing of the arch rings. For the arch rings and facing of abutments and spandrel walls cut stone will be used. Of this, two complete arches and the face ring of the remaining two arches will be sandstone from the Kettle River quarries of Minnesota; limestone from the Stone City, Ia., quarries will be used for the abutments, spandrel walls and inner sheeting of two arches. The arch rings will be 3 ft. deep, with ⅜-in. joints at the intrados. The filling over the arches will be of gravel, on which the ballast and track will be laid. This filling will be drained by 3-in. tile drains through the backing and arch sheeting.

Fig. 2 shows the style of centering for each arch. It consists of eight framed ribs spaced 3 ft. 10 ins. apart c. to c.; these are all supported on three intermediate bents of eight piles each, and by blocking on each foundation footing. Greased hardwood wedges are placed under the ribs and secured in place to prevent slipping. Lagging strips 4 × 5¼ ins. are placed at each voussoir joint.

The maintenance of uninterrupted traffic during the construction of the new bridge being necessary, it was decided that this could be accomplished most economically by shifting the four c'd spans with the track to one side of the proposed new structure. In their new position the spans are supported on one side by the up-stream end of the old piers, and on the other side by temporary pile bents. The spans were first jacked up 9½ ins. and the base plates and roller bearings removed. Rails were then laid on each temporary pier, at right angles to the track, and directly over these were placed inverted rails fastened to the trusses. Between these rails were placed double-hub cast-iron rollers. After everything was made ready, the four old spans were simultaneously moved to the north a distance of 17 ft. by one 20-HP. double-drum steam hoisting engine, lines being run to each end of each span. The moving was accomplished in about 35 minutes. The spans were then again jacked up, the rails and rollers removed, and wood blocking substituted.

A strip of land adjacent to the company's right of way at the west end of the bridge, was rented for use as a stone yard. Here, two steam fall and hand boom line derricks are employed in unloading. From the yard to the bridge the stone is carried on push cars which run on a track laid for this purpose. This track extends the full length and above the north half of the new bridge at a level with the proposed base of rail. A derrick is located at the center of each pier, and at the abutments: these are raised on temporary frame supports, so as to enable them to set all of the stones from the key courses of one arch to that of the adjacent arch. All of these derricks are operated by steam power. The derricks, trestle and centering, with the work in progress, are shown in Fig. 3.

The estimated cost of the entire work is $40,700, which includes about 4,000 cu. yds. of masonry, temporary bridge, removal of old structure, excavation, centering, filling, ballast and new track. The old bridge was moved on Aug. 17, 1902, and it is expected that the bridge will be completed by March, 1903. As is customary on this road, the construction is being done by the Bridge and Building Department, of which Mr. C. F. Loweth, M. Am. Soc. C. E., is the Engineer and Superintendent. Mr. J. C. Hain, Engineer of Masonry Construction, has immediate supervision of the work.

A METHOD OF CALCULATING THE RANGE OF SPEED TO BE OBTAINED FROM A PAIR OF EQUAL CONES.

By Frank B. Kleinhans.*

A problem that invariably confronts one in the design of belt-driven machinery, is the changing of speeds, and in machine tools, the range of speed is perhaps greater than is required for any other class of machinery. The cone is mostly used for this purpose, and perhaps will be for many years to come. Although inferior to a geared drive in some respects, yet its simplicity is an advantage which makes it preferable to gearing in many cases.

The problem which is here considered is the range of speed which is obtained from a pair of equal cones. The cases where the cones are not equal are very rare indeed. The accompanying illustration shows a pair of equal cones, in connection with a first and a second back gear. These are arranged to obtain the range of speed for a boring mill, but the same arrangement will apply

FIG. 3. CONSTRUCTION OF THE STONE ARCH BRIDGE AT WATERTOWN, WIS.: C., M. & ST. P. RY.

*2509 Park Ave., Cincinnati, O.

to any other machine where such a range of speed is necessary.

In the following computation, we will let n = number of steps; a_1 = diameter of small step of the cone, and a_2 = diameter of large step of the cone. In the case shown in the illustration, n = 6; $a_1 = 19$, and $a_2 = 34$.

$\left(\frac{a_2}{a_1}\right)^{\frac{2}{n-1}}$ = The constant multiplier. (1)

$\left(\frac{34}{19}\right)^{\frac{2}{5}}$ = The constant multiplier for this case.

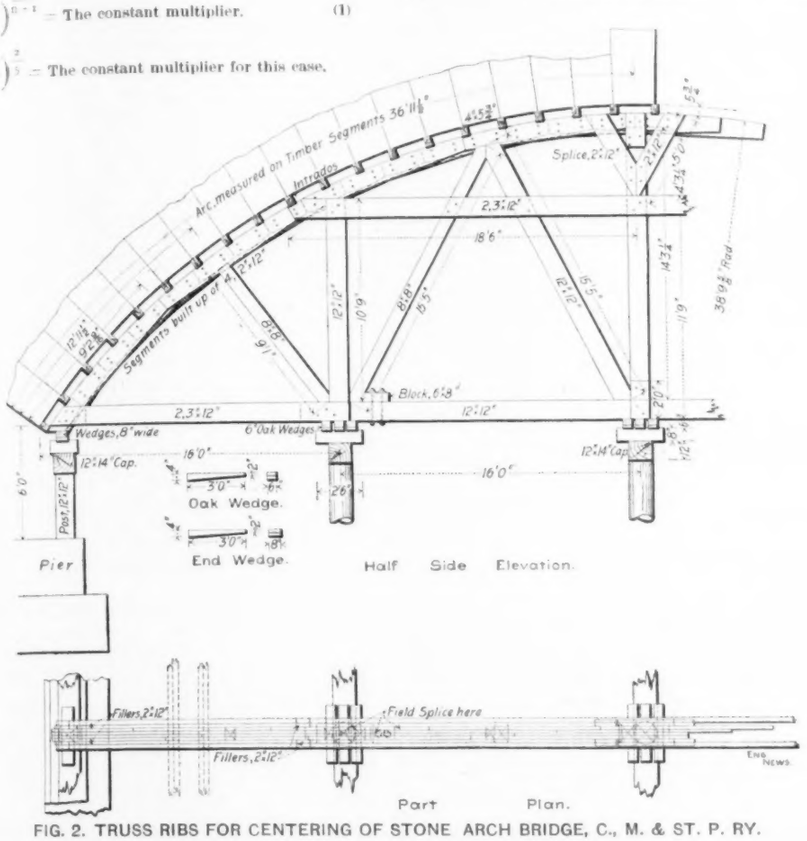


FIG. 2. TRUSS RIBS FOR CENTERING OF STONE ARCH BRIDGE, C., M. & ST. P. RY.

By applying logarithms, we have,

$$\text{Log}\left(\frac{34}{19}\right)^{\frac{2}{5}} = (\text{Log } 34 - \text{Log } 19) \times \frac{2}{5}$$

Log 34 = 1.5315
Log 19 = 1.2788
.2527
2
5) .5054
.1011

The number corresponding to this logarithm is 1.263, which is the constant multiplier for this case. That is, if you have the speed at which the cone will run, with the belt on the largest step of the machine cone, the next speed will be obtained by multiplying the known speed by this constant, thus:

1 = The 1st speed.
1.263 = The 2d speed.
$(1.263)^2$ = The 3d speed, etc.

and $(1.263)^5$ = The 6th speed = $\left(\frac{34}{19}\right)^{\frac{1}{5}\times 5} = \left(\frac{34}{19}\right)^1$.

Therefore, $\left(\frac{a_2}{a_1}\right)^1$ = The range of the cone. (2)

Only as many speeds can be gotten as there are steps in the cone, without going through some back gearing. Each cone has its proper back gear, and the ratio of this gear must be such as to continue the geometrical series of speeds given by the cone.

$\left(\frac{a_2}{a_1}\right)^{\frac{2n}{n-1}}$ = The proper first back gear. (3)

$\left(\frac{34}{19}\right)^{\frac{12}{5}}$ = The proper first back gear for this case = 4.04.

The first set of gears shown in the illustration must therefore be juggled so as to give this reduction of speed; of course, it cannot always be exactly obtained, but it should be gotten as nearly as possible.

$\left(\frac{a_2}{a_1}\right)^{2+\frac{2n}{n-1}}$ = The range of the cone and the proper first back gear. (4)

$\left(\frac{34}{19}\right)^{2+\frac{12}{5}}$ = The range of the cone and the proper first back gear for this case

$= \left(\frac{34}{19}\right)^{\frac{22}{5}} = 13.$

With the back gear marked first in the illustration, a range of speed, from 1 to 13, can be

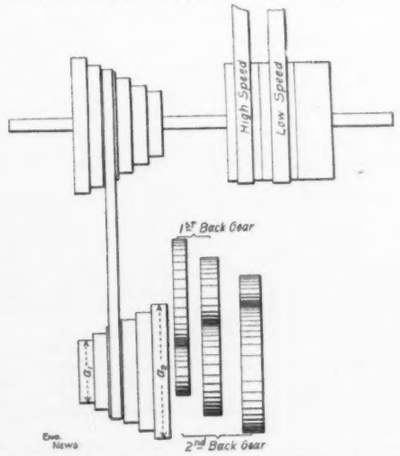


Diagram Showing Cone and Back Gear Arrangement for a Boring Mill.

obtained, but this range would not be great enough for this case, and a second back gear would have to be added.

$\left(\frac{a_2}{a_1}\right)^{\frac{4n}{n-1}}$ = The proper second back gear. (5)

$\left(\frac{34}{19}\right)^{\frac{24}{5}}$ = The proper second back gear for this case = 16.35.

The range for this case will be obtained thus:

$\left(\frac{a_2}{a_1}\right)^{2+\left(\frac{4n}{n-1}\right)}$ = The range of the cone and the first and the second proper back gears. (6)

$\left(\frac{34}{19}\right)^{2+\frac{24}{5}}$ = The range of the cone and the first and the second proper back gears for this case

$= \left(\frac{34}{19}\right)^{\frac{34}{5}} = 52.3.$

The speeds for the case considered have all been figured out, and have been arranged in the accompanying table for convenience and reference. It will be noticed that while the gap between the first two speeds is very small, yet between the last two speeds the gap is very great. For this reason, a two-speed counter is frequently resorted to. The second speed is such as to bring a speed midway between those shown in the table. Knowing one speed of the countershaft, the other can be obtained from it thus,

$$\frac{\left(\frac{a_2}{a_1}\right)^{\frac{2}{n-1}} + 1}{2} \times \text{by the low counter speed} = \text{the high counter speed.} \quad (7)$$

$$\frac{\left(\frac{34}{19}\right)^{\frac{2}{5}} + 1}{2} = 1.132 \text{ for the case considered.}$$

It will be noticed that if any speed in the table is multiplied by this number, it will give a speed midway between that one and the next higher. Sometimes a third back gear is added and the proper gear will then be obtained thus,

$\left(\frac{a_2}{a_1}\right)^{\frac{6n}{n-1}}$ = The proper third back gear. (8)

$\left(\frac{a_2}{a_1}\right)^{2+\frac{6n}{n-1}}$ = The range of the cone, and the first, second and third proper back gears. (9)

Table of Comparative Speeds by the Cone Arrangement Shown in Fig. 1.

A	Cone	1.00	1.26	1.59	2.01	2.54	3.20
B	1st back gear	4.04	5.10	6.44	8.13	10.30	13.00
C	2d back gear.	16.35	20.60	26.00	32.80	41.50	52.30

NOTE: Line A shows the range of the cone; lines A and B show the range of the cone and the 1st back gear; lines A, B and C show the range of the cone, the 1st and the 2d back gears.

RECORDING UNIT COSTS OF CONTRACT WORK.

By Emile Low,* M. Am. Soc. C. E.

At the annual convention of the American Society of Civil Engineers, held at Washington, D. C., May 21, 1902, an informal discussion was held on the following subject: "Is it possible and desirable to keep accounts of cost of work in such a manner as to ascertain unit costs on each class of work?"

Only a few members took part in the discussion, and their remarks were of a general nature, not going into details and methods by which definite results could be accomplished.

The writer desires to be placed on record as saying that the keeping of such accounts is very desirable and can be readily accomplished. In this connection he desires also to give his experience in this matter, and offers the following notes for the benefit of his fellow engineers.

In railroad construction it is almost the universal practice to keep an account of the forces employed by the contractor. These accounts, usually called "force accounts," are more or less elaborate, according as their value is rated by the Chief Engineer.

The data for these force accounts are collected by the Resident Engineer or some one of his party while passing over the work attending to his usual duties, the information being jotted down perhaps in the back of a note-book, or even on a stray piece of paper, an entire lack of system being the predominant feature of the method.

Usually these force accounts are rendered weekly to the Chief Engineer, upon blank forms furnished by his office. From the necessity of the case

*U. S. Engineer's Office, Buffalo, N. Y.

they are more or less approximate, furnishing no reliable basis for any compilation which would show the cost of the work to the contractor. At the best they merely show about what force was employed by the contractor.

During the construction of the Clinch Valley Division of the Norfolk & Western R. R., it was deemed especially important to keep an accurate account of all of the contractor's forces, whether engaged upon contract or upon extra work. On this railroad the work was not let by competition, but was parceled out to reliable contractors at unit prices fixed by the Chief Engineer.

Under "extra work" was included the excavation, cofferdams, etc., of foundations for all masonry structures, the expense of which was paid for at cost for labor and materials furnished plus 15% added for profit. The price paid for masonry included only the cost of quarrying and laying the stone, also the sand and cement, the contractor, of course, supplying the necessary plant and tools.

The railroad in question was about 100 miles long and divided into 103 sections, all except a few being each one mile long. The engineering organization comprised an engineer in charge, three division engineers and a number of resident engineers. The residencies were usually seven miles long, and five comprised a division. The work was let in contracts of various lengths, one contractor having 30 miles, others less.

In order that an exact account of the contractor's forces should be obtained, one member of the resident engineer's party was entrusted with this work. His duty was to pass over the entire residency each day, making in a pocket-book, especially prepared for this purpose, a record of every force employed.

These books were 4¼ ins. wide, and 7 ins. long. A fac simile of a double page is shown by Fig. 1.

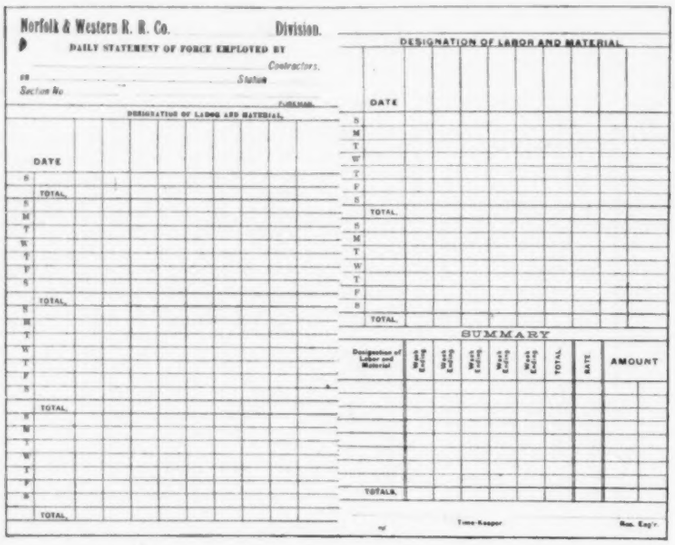


FIG. 1. SAMPLE DOUBLE-PAGE OF RESIDENT ENGINEER'S NOTE-BOOK FOR FORCE ACCOUNT (REDUCED ONE-HALF).

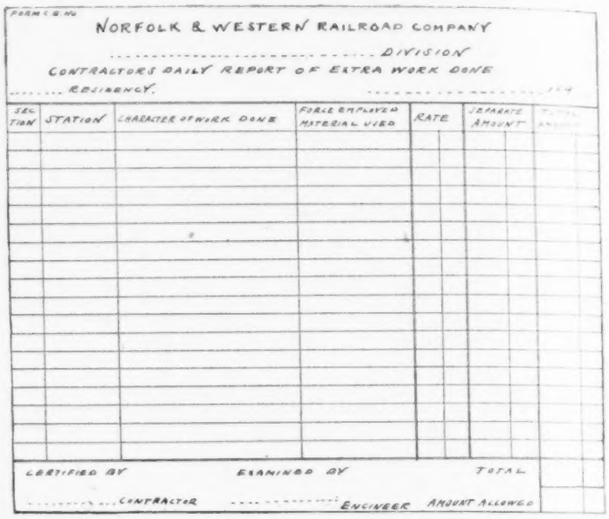


FIG. 6. BLANK FOR REPORTING EXTRA WORK.
(Redrawn from Official Map Accompanying Report of Board.)

It will be noted that a full double page is assigned to each individual piece of work, be it grading, masonry, bridge, trestle, tunnel, extra work, etc. The name of the contractor is also entered, as well as the section and station.

The rulings are so arranged that each week's work is kept separate. The weeks being totaled up at the end of the month, showing the whole

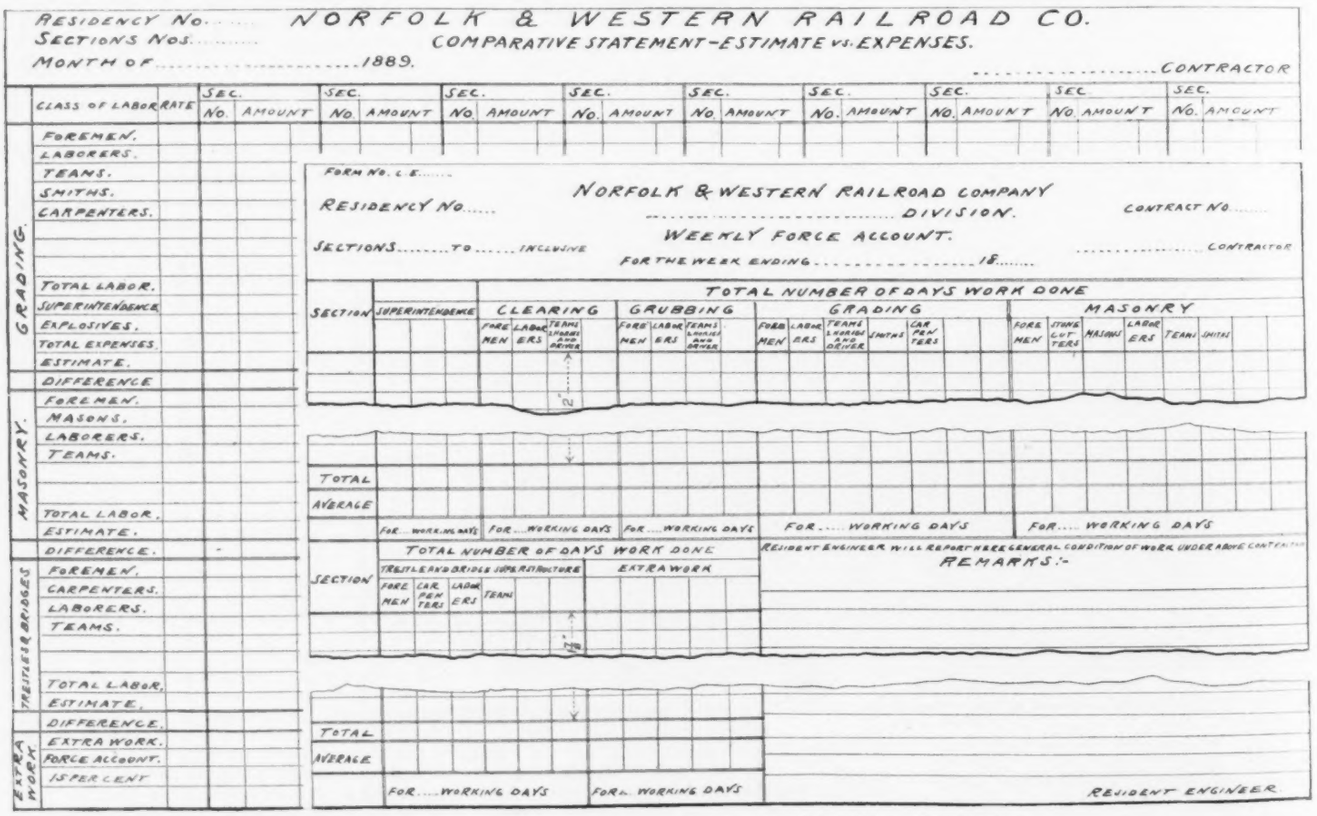


FIG. 4. COMPARATIVE STATEMENT OF ESTIMATE AND EXPENSES.

FIG. 2. WEEKLY FORCE ACCOUNT.

NORFOLK & WESTERN RAILROAD COMPANY

.....DIVISION.

WEEKLY REPORT OF PROGRESS, TUNNEL NO....., SECTION NO.....

FOR WEEK ENDING..... 18.....

RESIDENCY NO..... CONTRACTOR.....

WEST PORTAL STATION — EAST PORTAL STATION

EXCAVATION

HEADING. END	STATION LAST REPORT	STATION THIS REPORT	PROGRESS FOR WEEK	TOTAL PROGRESS	SIZE OF HEADING	NATURE OF MATERIAL	BOTTOM. STATION LAST REPORT	STATION THIS REPORT	PROGRESS FOR WEEK	TOTAL PROGRESS
TOTAL DRIVEN										
TO BE DRIVEN										
TOTAL LENGTH										

TIMBER

HEADING END	STATION LAST REPORT	STATION THIS REPORT	PROGRESS FOR WEEK	TOTAL PROGRESS	NO. OF BENTS	DIST. C. TO C. BENTS	BOTTOM STATION LAST REPORT	STATION THIS REPORT	PROGRESS FOR WEEK	TOTAL PROGRESS	NO. OF BENTS	DIST. C. TO C. BENTS
		TOTAL										

TUNNEL PACKING

HEADING END	STATION LAST REPORT	STATION THIS REPORT	PROGRESS FOR WEEK	TOTAL PROGRESS		BOTTOM STATION LAST REPORT	STATION THIS REPORT	PROGRESS FOR WEEK	TOTAL PROGRESS
		TOTAL							

FORCE

END	WORKING DAYS	STEAM DRILLS	BOILERS	SUPERINTENDENTS	FOREMEN	DRILLERS	ASST. DRILLERS	FIREMEN	LABORERS	LABORERS			CAR PUSHERS	BLACKSMITHS	HORSES	CARS			
HEADING																			
"																			
BOTTOM																			
"																			
TOTALS																			

REMARKS

RESIDENT ENGINEER.

FIG. 3. FORM OF PROGRESS REPORT ON TUNNEL WORK.

month's work. It sometimes happens that one month covers six weeks, four whole and two partial weeks. This can, however, occur only when the month comes in on Friday or Saturday, which contingency is provided for in the time-book.

On the railroad mentioned the residencies were usually seven miles long, consisting of seven sections, each of one mile. It is not likely that there would be over ten working forces for each mile, but to be sure it would be well to have time-books of 100 leaves or 200 pages, or perhaps, better still, books of 50 leaves, using as many books as might be necessary.

For convenience it is well to keep the working forces in the order of the stationing of the line; the sections would then also be in consecutive order. These daily reports also furnished the data for the weekly force account, which was regularly sent to the Chief Engineer's office every week.

This report, Fig. 2, showed the total number of days' work done on each one-mile section, under the different heads of superintendence, clearing, grubbing, grading, masonry, trestles and bridges and extra work.

The work on tunnels was shown on a separate report, Fig. 3.

Of course, the method employed in collecting the data does not give absolute accuracy, as the forces employed might not be the same for the whole day. To give better results the line should be patroled twice a day, but in this case the time-keeper should be provided with a horse in order to get over the ground more rapidly. However, for practical purposes, the record taken once a day will be found to be quite satisfactory.

At the end of the month the Resident Engineer submitted with his regular monthly estimate a report termed, "Comparative Statement—Estimate vs. Expenses." This statement is compiled from the time-book previously mentioned. The statement, Fig. 4 and Fig. 5, shows in detail for each section the different classes of labor employed and materials used in grading, masonry, trestles, bridges, tunnels and extra work, and amounts of same.

The gross estimate for each class of work is also given, the difference between the two amounts, showing gain or loss as the case may be.

On the back of the report the separate sections covered by the residency are summarized, each class of work being entered separately, the totals being entered in red ink. Separate reports for each contract were made, in cases where there were two or more contractors on a residency.

Tunnels occurred only on some of the residencies. When they occurred the force accounts were shown on the back of the report, provision for this being made.

As some of the contracts covered several residencies it was necessary in these cases to combine the reports of the several resident engineers, and a special blank similar in general to Fig. 5 was used for this. As previously stated, a great deal of extra work was done by force account, that is, the contractor was paid for the actual cost of labor and materials expended, and to this 15% was added for profit.

In order to keep a proper account of this work, the contractor was required to submit a daily report of all extra work done. The blank reports were furnished by the railroad company and are shown by Fig. 6.

These reports showed in detail the sections and stations where the work was done, also the character of the same, as well as the force employed and materials used.

These reports, as soon as rendered by the contractor, were compared by the Resident Engineer with the railroad company's timekeeper's book and if found correct were so indorsed. If otherwise, they were returned to the contractor for correction, or in case of dispute all differences were properly harmonized.

The accounts were also entered daily in a book provided for that purpose, a page of which is shown by Fig. 7. At the completion of the work, or always at the end of the month, a summary was made, giving total items, rate and amounts from which a voucher was prepared for payment.

Whenever possible, measurements of all extra work were made, from which unit prices could be calculated.

The essential feature of the system above described is the detailed completeness with which the data is recorded, thus making it possible to secure accurate unit costs.

One firm of contractors which built a large number of miles of this railroad used a system of accounts somewhat similar. In their regular time-books, for each excavation, piece of masonry, or other work, a separate page was assigned, the

NORFOLK & WESTERN RAILROAD CO., DIVISION. 61

MONTHLY REPORT OF EXTRA WORK

Residency No. ..... Section No. ..... Contractor.

Kind of Work .....

LABOR AND MATERIALS.

Rate. Date.	AMOUNTS. Dollars.	Cents.
Totals.		

SUMMARY.

No.	ITEMS.	Rate.	AMOUNTS.	REMARKS.

Engineer.

Total Amount for..... 189 Continued on Page.....

FIG. 7. SAMPLE PAGE OF BOOK FOR RECORDING EXTRA WORK (ACTUAL HEIGHT OF PAGE, 8¼ INS.)

names of the workmen only who were engaged in the particular work being entered. In case of shifting of forces men's names would appear in the time-books on several jobs during the month. All material, such as powder, dynamite, fuse, etc., were also charged to the particular work on which they were used. It was then an easy matter at the end of the month to determine the cost of each piece of work. The railroad company's engineers furnished the contractor the exact quantities. The contractor could then readily determine how each piece of work was running, and in case of loss, apply the proper remedy.

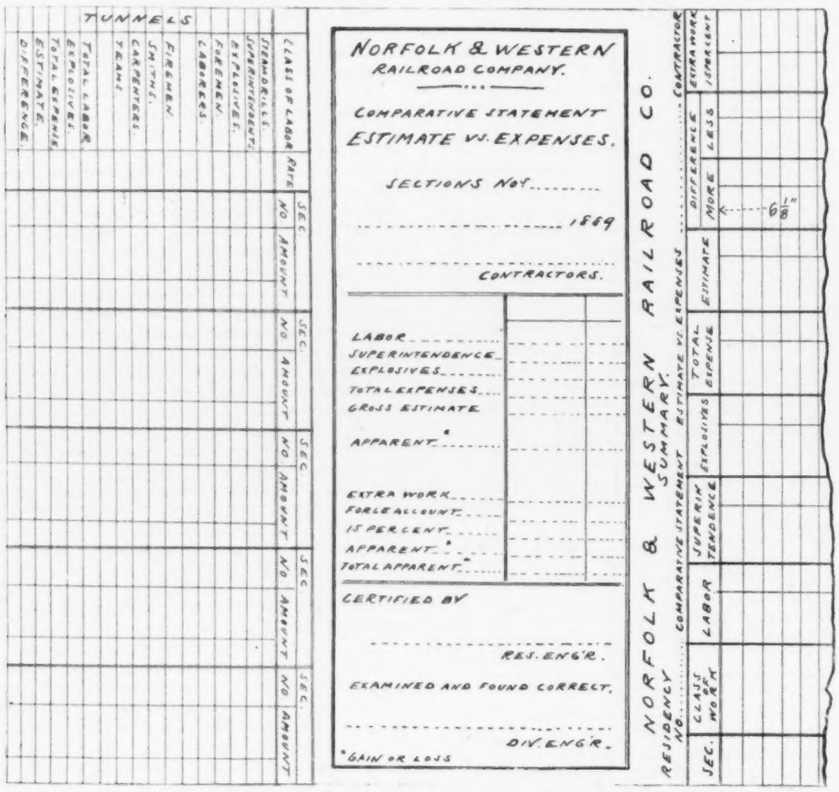


FIG. 5. SUMMARY OF ESTIMATE VS. EXPENSES.

ERECTION OF THE MIRAMICHI BRIDGE BY AID OF SCOWS.*

By H. D. Bush,† M. Can. Soc. C. E.

The broad tidal river, the Miramichi, is formed about one mile above Newcastle, New Brunswick, by the junction of two branches, called respectively the Northwest and Southwest Miramichi. The head of navigation for ocean-going craft is about two miles farther up each branch, where both are crossed by wooden highway bridges and, just above these, are the single-track bridges of the Intercolonial Railway. The latter are structures of some interest historically, and were built from about 1870 to 1874, the engineer being (Sir) Sandford Fleming, the contractors for the substructure, Brown, Brooks & Ryan, and for the superstructure, Clarke, Reeves & Co.

The piers are of native sandstone with granite faced cutwaters, and are being used without alteration to support new and heavy superstructures, that over the Northwest River having been erected in 1902, and that over the Southwest River to be erected in 1903.

The foundations were made by sinking open double-walled caissons for the Southwest bridge, the material being dredged out through wells until a suitable bearing on a thick stratum of gravel was reached, and the caisson then filled with concrete. At the Northwest bridge, rectangular cribs were used with two rows of sheet piling driven inside, and the enclosed space dredged out, and filled with alternate layers of concrete and rubble stone. One pier settled 10 ins. during construction, but under a test weight, greater than that it had to carry, and left on several months, it settled only 2½ ins. more. Investigation showed the settlement to have been wholly within the caisson, and not due to compression of the gravel foundation.

The floor system of the old Phoenix spans was strengthened in 1888 by the addition to each floor beam of two 2¼-in. square truss rods, and by the replacing of the original floor beam hangers by new ones 2 ins. in diameter. A heavy lower lateral system was at the same time added.

The old spans so far taken down show a remarkable state of preservation. The insides of the columns, apparently coated by dipping in something like a pipe compound, are entirely free of scaly rust and show only slight discolorations from rust after 30 years of use. The pin nuts have unscrewed more easily than expected, and the pins show practically no signs of wear.

The old spans have each 14 panels of 14 ft. 7 ins., making them 204 ft. 2 ins. long between end pin centers. The floor beams are 24 ins. deep, with flange angles, 4 × 4 × ½ ins. The two lines of stringers are 16 ins. deep with 3 × 3 × ⅜ in. flange angles and rest on a small shelf angle, and are each connected to the floor beam webs with six ⅝-in. bolts. There are wooden cross-bearing beams, under the ends of the old stringers, on all the piers and abutments, the pockets in the masonry being about 30 ins. deep.

The new spans are heavy riveted trusses each with seven panels of 29 ft. 4 ins. The floor beams, 72½ ins. deep, are entirely below the lower chords and riveted between the vertical web members of the trusses, which extend down through the chords. There are four line of stringers, 48½ ins. deep, spaced 3 ft. center to center.

In the end stringers the bottom flange angles are brought up in a reverse curve to reduce the depth at their outer ends to 33¾ ins. to fit the pockets in the masonry.

The new bridges are designed in accordance with the Intercolonial Railway specifications of 1901, the uniform live loads per lineal foot for the several parts being as follows:

Trusses	5,900 lbs.
Floor beams	6,750 "
Main stringers	9,100 "
Connections of main stringers and floor beams	10,600 "

It was suggested in these specifications that the old spans be removed bodily by means of scows with trestle work thereon, Fig. 2, taking advantage of the rise and fall of the tide. The spans were to be rolled back on trestle work, built on the south shore, below the bridge, so as to be in a position for sliding down to the deck of a barge for transportation to Prince Edward Island, where they are to be used.

The method of erection of the new trusses and removal of the old ones as outlined in these specifications was adopted by the Dominion Bridge Company, Ltd., the contractors for the new bridges. The original idea of transporting each old span, entire, on a special scow, to Charlottetown, has been abandoned, and they have been taken apart at the shore ends of the landing trestles, Fig. 1. The center lines of these trestles are 204 ft. 2 ins. apart, and, in the Northwest River there was barely room for them between the railway and highway bridges; in fact, the up-stream trestle could not be constructed until the span adjacent had been replaced.

Four scows (Figs. 2 and 3) were built for this work, each 84 × 26 ft. and 8 ft. deep. There are five longitudinal Howe trusses in each scow, Fig. 5, spaced 5 ft. 3 ins. center to center. Two scows were used for each truss, both old and new. As the old trusses required a support at each panel point, a Howe truss bridge was built crossing over the two scows, and projecting three panel lengths at each end, the scows being spaced four panel lengths apart, Figs. 3 and 6. The chords of these trusses were 12 × 24 ins., made up of 3 × 12-in. planed planks, bolted together to make a net section equal to about 10 × 18 ins. for a calculated maximum chord stress of 136,000 lbs.

On account of the truss rods projecting below the floor beams of the old spans, blocking was hung at each end of each floor beam so that the lower surface of the blocking was just below the metal work. These blocks were always in place before a span was lifted. As the work in 1902 was done at a season of comparatively low water, additional blocking, varying from 8 to 21 ins. in depth, was used on various spans. Pieces of 8 × 10 ins. and 5 × 10 ins., 2 and 3 ft. long, were always kept on the top chords of the Howe trusses at the panel points, so that this additional blocking could be quickly adjusted.

The first old span lifted could not be unloaded until the up-stream landing trestle was nearly completed, and this span was carried on the scows for six days. The second old span was also kept afloat for four days in the main river channel, from which position it could not be moved on account of heavy winds.

The Howe trusses used in connection with lifting the old span are shown in Fig. 4. Each of the scows used with the Howe truss carried a 6-in. centrifugal pump with connected engine, the two engines being run from one boiler on one of the scows, from which steam was piped to the other scow. Each scow also had a 6-in. gate valve, placed on one side, close to the bottom, and controlled from the deck. Water could be let into these scows at the rate of slightly over one foot an hour and pumped out of both simultaneously at the rate of 1½ ins. a minute. The scows used under the new spans had two 6-in. gate valves each, and two diaphragm pumps. These scows were generally placed under the spans with about 8 ins. of water in them, this being pumped out by hand, and the balance of the lifting done by the tide.

The new trusses were erected on twin falseworks placed side by side, Fig. 1, each one just long enough for one span, and situated on the south shore, just far enough up stream to allow the 84-ft. scows to pass between the falsework and the bridge pier. There were two openings through which the scows could be passed, these openings dividing each falsework into three towers, one of one panel, and two of two panels each. Short trestles connected the falsework with the top of the river bank, and the tracks from the unloading derricks.

I-beams were used as stringers in the falseworks, partly because the contractors had them in the vicinity of this work from another contract, and largely because of the increasing difficulty in buying long timber.

The spans were erected by a two-boom traveling derrick, running on two rails spaced 10 ft. center to center. The working platform was about 10 ft. above the rails, and so supported as to leave room for a standard gage track beneath it, on which track material was pushed forward on lorries, ready to be handled by the booms. As soon as one span was erected, the traveler was pulled over on greased rails to the second falsework, and a second span erected while the first was being riveted. One 10 × 10-in. air compressor, run with steam from two upright boilers, furnished power to the air riveters used.

Fig. 1. Showing Erection of New Miramichi Bridge. Spans on Trestles.

*A paper read before the Canadian Society of Civil Engineers at the Annual Meeting, Jan. 27, 1903.

†Engineer Dominion Bridge Co., Montreal.

This plant was placed at the top of the river bank. Water was taken from a "spring," which was found near the base of the south abutment, and was, in reality, an artesian well, the flow of water coming from a bore hole, sunk by the engineers 30 years ago to determine the characters of the abutment foundations. A hot-air engine forced the water up the bank. The rate of progress was determined by the time required (about nine days) for riveting each span. It was impossible to get experienced men enough to run more than four air riveters.

On each of the scows, used for floating the new spans, five trestle bents (Fig. 5) were erected with four legs in each bent, making for the two scows a total of 40 posts, each 8 × 9 ins., to carry the weight of the span, which, with the track in position, was 640,000 lbs. The trestles were 20 ft. 7 ins. in height and well braced in four directions. The legs in each bent were spaced 3 ft. centers on top, and battered as shown, so as to distribute the loads to the Howe trusses in the scows as had been calculated.

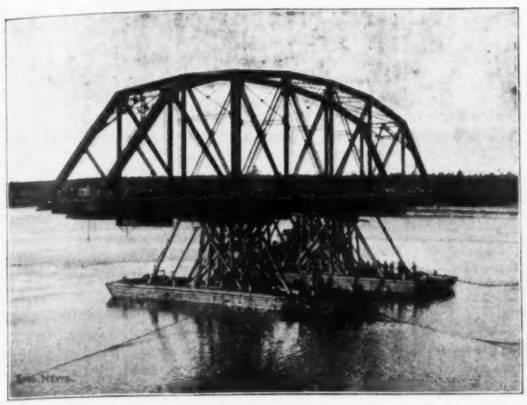


FIG. 2. MOVING A NEW SPAN TO PLACE ON SCOWS.

FIG. 3. REMOVING AN OLD SPAN ON SCOWS.

The trestles on each scow took their loads from the four track stringers in the next to the center bridge panel, leaving two panels projecting at each end. On account of the narrow base, 9 ft., afforded by the track stringers, six side braces, three on each side, were also used on each scow, and extended from the lower chords of the span to bearing blocks, which were spiked to the deck of the scows, directly over the center and outside Howe trusses.

Longitudinal and cross 8 × 10-in. and 5 × 10-in. timbers were provided to go on top of the trestle bents to build them up 8 ins., 16 ins. or 21 ins. higher. Different thicknesses of this blocking were used to float different spans, according to the height of tides expected.

After starting work it was found that the information previously obtained concerning the tides was inaccurate. A fairly regular rise of nearly 4 ft. had been counted on. As soon as gages were established the records showed the average rise to be considerably less than 3 ft.

As the end stringers hung down 30 ins. below the bed plates of the new span, it would have been necessary to float the span 30 ins., plus at least 10 ins. for clearance, or 40 ins. above its final level, or more than the average rise of the tide. It was, therefore, decided not to rivet these stringers until the spans were in place. The ends of the stringers were lifted up, until their bottom flanges were about on a level with the bed plates of the span, and lashed to a 14 × 14-in. cross timber resting on the bottom chords of the truss close to the end gusset plates. The falsework had already, before this change in plan was made, been built to carry the new spans 24 ins. above their correct height. As soon, therefore, as a span was afloat it was high enough to clear the masonry 2 ft. and plenty of time could be taken to land it, even on a falling tide, but time was saved by having a less distance to lower than originally contemplated. There were only two days out of five in which spans were floated, in 1902, when the tide rose high enough to have lifted the spans clear of the masonry if the stringers had been left level. One of these tides was unusual and lifted the second span 5 ft. 4 ins., while the usual tide raised the spans about 26 ins. above correct height. The scows drew 4 ft. loaded, leaving 4 ft. of freeboard. Water could safely be admitted to lower the scows 30 ins., still leaving 18 ins. of freeboard. It would have been safer and quicker to have been able to reverse these figures by having the falsework one foot lower. There were two cross bulkheads in each scow to prevent the water in them from rushing to one end in case of tilting by the wind.

For the placing of each span, a day was selected when there promised to be a suitable tide coming at a time of day to least disturb railway traffic. At low tide the Howe truss and two scows were placed under the old span, the wooden blocking having been previously suspended from the ends of the floor beams, and the other scows were placed under the new span. If the tide seemed to be coming up to expectations and if no strong wind started, the track was cut about two hours before high tide and the end panels of the flow system of the old span removed. In the meantime sufficient water was let into the Howe truss scows to just keep the old span from lifting. As soon as the new span was safely afloat the scows under the old span were quickly pumped out with the centrifugal pumps, so that after a few minutes the old span could be pulled to one side and the new span brought into position.

The new span was held by two cross tackles at each end, as well as by anchor lines on the scows. As soon as the new span was safely in position the end stringers were lowered to their correct level, and, as soon as the tide had turned, the valves in the scows were opened, and the span lowered. There was a delay of several hours in placing the second span, due to the unusually high tide which, as already noted, lifted this span over 5 ft. too high. There was also a delay with the fourth span, on Nov. 12, when the tide lifted the span over 3 ft. above its correct height. There was a strong up-stream wind which held the tide for two hours, so that it was feared it might rise still higher. No water was let into the scows until the tide had definitely turned, and this delay threw the work of connecting the track into the night. It was necessary in the Northwest bridge to wait for a fairly high tide to lift the new span, on account of the shallow water close to the south shore. Pockets had to be dredged for the inshore scow, Fig. 7, both under the falsework to get this scow low enough to go under the spans, and under the bridge to enable this scow to be sunk low enough to land the first span. On the Southwest bridge, with comparatively deep water close to shore, it will be easy to supplement an insufficient tide by admitting water into the scows before they are blocked under the spans, and pumping it out again as the tide rises.

Span No. 1 was floated at 21 o'clock, Thursday, Oct. 9, and was pulled about 100 ft. into deep water. This span the railroad officials positively refused to have placed until Sunday, on the ground that, until at least one change had been made, there was no way to tell exactly how long it would take, and that they could not afford to have the road open for an indefinite time, except on Sunday. The contractors took the risk of holding this span afloat for three days and nights in order to get the use of the falsework to begin the erection of another span. There were very strong down-stream winds during this time, half a gale on Friday, Oct. 10, when it was wished that the risk had not been taken. This span was placed in position at noon, Sunday, Oct. 12, and a freight train crossed over it at 16.30 o'clock. Span No. 2 was placed on the north shore, being towed across the river, just at dusk, Sunday, Oct. 19, and landed about 9 p. m., as the tide on this night rose for two hours after schedule time. The remaining spans were placed in succession, working from the north towards the south shore, as follows: Span No. 3, Friday, Oct. 31, at 17 o'clock, and span No. 4, Wednesday, Nov. 12, about 18 o'clock, in a snowstorm, and a strong easterly or up-stream wind, which, although making it harder for the two tugs employed to handle the span, made it certain that, in case of any accident, the scows would be blown away from, instead of towards the old bridge. Span No. 5 was placed at about 15 o'clock, Tuesday, Nov. 25. Passengers on one local train were transferred on the days that spans 4 and 5 were placed. It was planned to place span No. 6 on Sunday, Nov. 30, but two intervening days of bad weather made it impossible to get the span riveted in time. This span was to take the place of the second old span out from the south shore, as arranged, so that the distance to move the last span would be as short as possible in case ice formed, as expected, before it could be floated. Riveting was finished on the morning of Dec. 3, when the field ice which had been moving up and down stream with the tides for a week previous, was pretty well caught together, leaving some openings in the center of the river. High tide now came at about 9 and 21 o'clock, with the former averaging about one foot too low and the latter one foot too high. It was, therefore, necessary, on account of the shallow water, to hold this span on the falsework for a few days until, as the time of high tides approached noon and midnight, the day tide would increase in height. The scows were placed under this span about 3 a. m., Sunday Dec. 7, with the expectation that the final change could be made on the following high tide at about noon. The cold snap which, for some time after this date, prevailed over the whole north, began on the Miramichi this night. At 5 a. m. the thermometer registered 18° below zero, and by daylight the workmen could walk on the ice, where at midnight there had been open water. The temperature remained so low during the following week that it was found impossible to cut a large enough opening in the ice to enable the span to be floated and pulled out into deep water during one high tide. It was therefore decided, on Saturday, December 13, to leave the last span on the falsework until next spring, when the contractors would have a force of men on the ground for work on the Southwest bridge.

As the first span was floated on Oct. 9, and the sixth span ready on Dec. 3d, the rate of progress for five spans was about nine days per span, there having been 44 working days included between these dates.

FIG. 4. SHOWING TWO NEW AND TWO OLD SPANS OF THE MIRAMICHI BRIDGE.

The old spans were landed in two trucks each having eight 24-in. double-flanged wheels (four wheels under each corner of the span) running on a track with rails 24 ins. center to center. The wheels revolved on 4-in. axles, two at each end of the truck, spaced 3 ft. 8 in. center to center. The 12 × 12-in. × 24-ft. timber used for the frame of the truck was strengthened for bending between the axles by having a piece of 12-in. channel bolted on each side. Heavy cast-iron blocks, under the timbers, extended from end to end of channels and provided the bearing over the axles. The bed plates of the old spans rested on heavy timbers about 6 ft. long, placed across the trucks at each end between the axles. The trestles supporting the tracks extended out about 150 ft. from shore into sufficiently deep water for floating the scows. The scows were turned to bring the span at right angles to the line of the bridge, or parallel to the shore, the scows hauled back at high tide until the bed plates were over the trucks, water admitted to the scows until the span came to a bearing, and the scows and Howe truss were then freed partly by letting in more water, and partly by the falling tide.

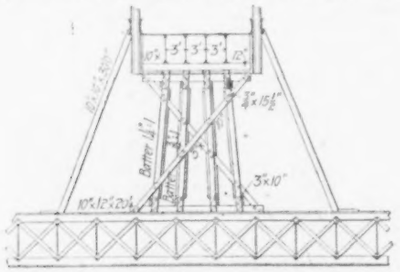


Fig. 5. Showing Trestle on Scow for Supporting New Bridge Span.

When a span had been rolled back to its correct position on the landing trestles, ship jacks were placed underneath the trucks, between the rails, and the trucks and span lifted a few inches. Blocking was then built up from the caps of the trestle bents to the projecting ends of the cross timbers on the trucks, the jacks were then released and the trucks rolled forward ready for another span. On account of the concentrated loading the bents of the landing trestles were spaced only 8 ft. apart. The stringers under each rail were made up of two pieces of 12 × 12 ins. on top of each other, breaking joints over the bents.

The trucks were made by the contractors, who loaded and rolled back the old spans.

The trestles were built by the railroad company, who took down the old spans, using an ordinary square outside traveler, running on blocking and short trestle bents at the top of the river bank, at the inshore ends of the landing trestles.

The calculations and plans for the erection work were made under the general direction of Phelps Johnson, M. Can. Soc. C. E., by the writer, who had charge of the work for the contractors. Wm. B. Mackenzie, M. Can. Soc. C. E., was chief engineer of the Intercolonial Ry. Co

SOME RECENT TESTS OF MECHANICAL STOKERS.

By G. A. Hutchinson.

So much has been written concerning the advantages of firing steam boilers mechanically that the accompanying report of tests made on two representative types of mechanical stokers will be of interest to many engineers. The difficulties encountered are of a general nature rather than being peculiar to these particular makes of stokers, and for obvious reasons the names of the stokers, and location of the installations will not be given.

The corporation which purchased these stokers operates two coal mines. For purposes of accounting, the cost of mining is assumed to be the same at each mine. The cost of mining plus the freight rate is the price which the departments using the coal are charged per ton. The Schlecht coal, hauled some 200 miles by rail, is a very low grade fuel, but when properly fired on shaking grates of sufficient area answers well enough for steam purposes. The Besser coal, being hauled twice as far, is more expensive. It is much better in quality and is used for other purposes, as the Schlecht coal is cheaper for power generation.

Two Heine water-tube boilers were equipped in the summer of 1901 with stokers of the sloping grate variety, where the coal is moved downward from a magazine by the movement of the grate bars. Schlecht lump coal was used ordinarily, first being broken to a suitable size, and then elevated to an overhead hopper. The coal, now used altogether for hand-firing, which has been broken and washed at the mine, but not screened, was tried. It had to be given up because the ash and fine coal rapidly filled the combustion chamber and smelted into a slag-like mass. The path of the burning gases was restricted, and such an intense heat was concentrated on the tubes that they rapidly gave out.

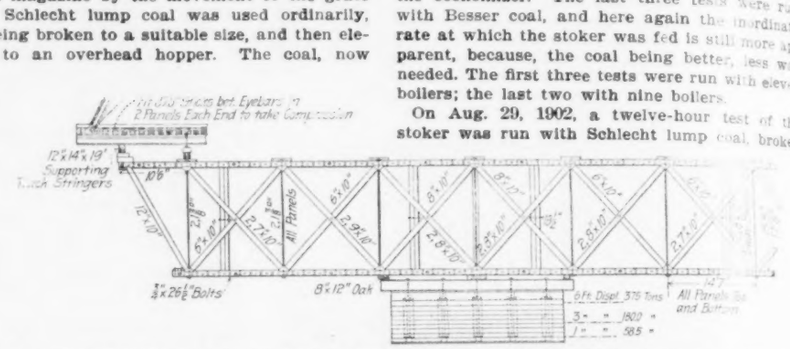


FIG. 6. HOWE TRUSS ON SCOWS FOR SUPPORTING OLD BRIDGE SPAN DURING REMOVAL.

On July 22-23, 1901, a 24-hour test was conducted with Schlecht lump coal, the furnace being under the management of the builders' representative who installed it. The economy was neither better nor worse than has frequently been obtained with the same coal hand-fired. It was in fact about as good as can be gotten with this coal, and much superior to everyday practice. The draft was very poor.

During the fall and winter of 1901 the whole boiler plant was overhauled, the economizer installation enlarged, an induced draft fan put in, and, in the summer of 1902, five 24-hour tests of the whole plant were run, when some 2,800 or 2,900 boiler HP. was developed. It was necessary, during these tests, to weigh separately the coal used by the automatic stokers. No provision was made for determining the evaporation of that pair of boilers independently, as the reason for running the tests was to determine the average economy of the plant when running with and without the economizer, and to compare the coal received from the No. 1, No. 2 and No. 4 Besser mines. The firemen were supposed to work in their usual way without interference or suggestion from anyone up as usual. The firemen work eight hours a day, coming on duty at 7 a. m., 3 and 11 p. m. For this test the best man from each crew was chosen. They are men who show excellent judgment in the management of fires on common grates, and who are used to the stoker in question. They were allowed to manipulate it as they pleased, and there is no reason to believe that they did not do as well as they knew how, other than that they, perhaps, worked the boilers harder than usual, the coal consumption being 0.76-lb. per sq. ft. of heating surface per hour. The result almost broke the record. One other test only, of the fifty odd which the writer has conducted, shows so poor a result. The equivalent evaporation from and at 212° per pound of coal as fired was 4.734. With the same fuel and the most indifferent handling on a 24-hour plant test when the trial is made merely to ascertain the average performance, we get an equivalent evaporation of 5 to 5¼ lbs. So far as the capacity is concerned, the adjoining pair of boilers, alike in every particular, but hand-fired, were worked harder, with far greater economy, by the same firemen a couple of days before, with Schlecht washed coal, which, as stated elsewhere, cannot be used in the automatic furnace.

The first test was with Schlecht coal and the economizer in service. The second test was with the same fuel, but without the economizer. The amount of coal fed to the stoker was about the same on both tests, and the hand-fired boilers had to take the extra load entailed by cutting out the economizer. The last three tests were run with Besser coal, and here again the inordinate rate at which the stoker was fed is still more apparent, because, the coal being better, less was needed. The first three tests were run with eleven boilers; the last two with nine boilers.

On Aug. 29, 1902, a twelve-hour test of the stoker was run with Schlecht lump coal, broken

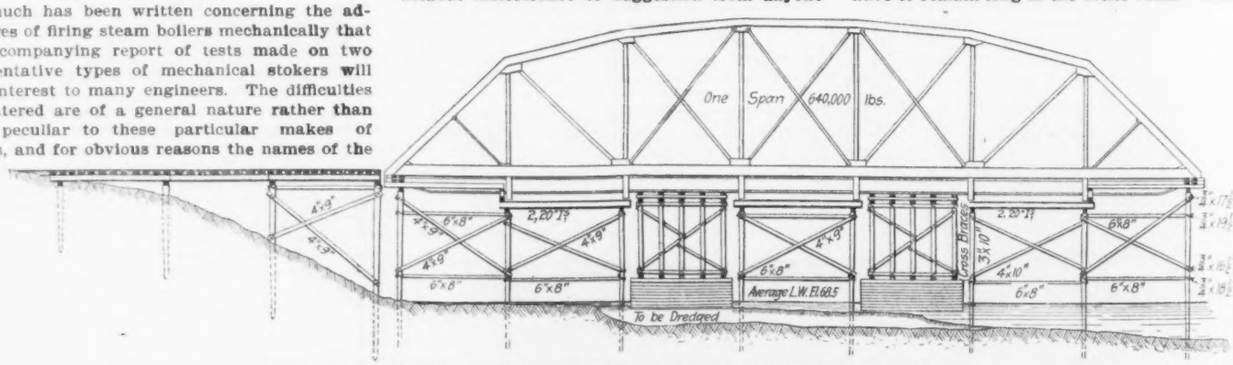


FIG. 7. NEW BRIDGE SPAN ON TRESTLE READY FOR REMOVAL BY SCOWS.

The stoker advocates will say that the firemen must be trained to run the stoker economically. Men in charge of plants are likely to reply that a man who is sufficiently intelligent and interested in his work to make a first-class fireman, will not have to remain long in the boiler room. With this stoker Besser coal cannot be used regularly because the ash fuses into tremendous clinkers which can only be removed with great labor and inconvenience.

In the course of the test it was noted that the automatic stokers received much more than their just proportion of the fuel, and afterwards the following comparison was made:

Date of test	June 17-18.	June 18-19.	June 25-26.	July 7-8.	July 8-9.
Lbs. coal burned per sq. ft. boiler heating surface per hour: Mechanically fired	0.89	0.70	0.92	0.63	0.59
Hand fired	.42	.52	.32	.40	.40
Economizer in service	Yes.	No.	Yes.	Yes.	Yes.
Coal	Schlecht.	Schlecht.	Besser.	Besser.	Besser.
Boiler heating surface, sq. ft.	30,540	30,540	30,540	25,310	25,310
Horse-power developed	2,891	2,902	2,746	2,853	2,817
Tons of coal fired	171½	202½	138	136½	135½

In the spring of 1902 a pair of chain grates were installed under a 300-HP. water-tube boiler. The builders sent a man to start it. He labored a long time with the Schlecht coal, but could not make it burn. The furnace remained cold, and if a fire was started it burned in spots, leaving much unconsumed coal to be heaped up at the bridge, or dropped into the ashpit. With the other furnace, where the coal works down from above onto a flaming bed, there is no difficulty about ignition, but where the fuel is carried along on a comparatively cold grate it apparently cannot be made to burn if too poor in quality. Besser slack coal was tried with more success, and a couple of tests were run. Two cars had been set aside for this purpose. The first, used May 24, came from the No. 1 Besser mine, had some coarse material in it, such as would pass through a 1¼-ring, and was very good. The grate worked excellently, maintaining a very steady fire, and a hot furnace, without loss of time for poking or cleaning. No clinkers were formed, and there was no accumulation at the bridge. Some very fine coal dropped through on to the floor at the front, and had to be shovelled back into the hopper. As the flue temperature readings seemed unreliable they are not given. On May 26 the coal used was poorer, coming from the No. 2 mine. It was more like meal, containing few small lumps, and the boiler could not be worked to its rating, falling short 22.6%.

In view of these tests it seems that the economy claimed for mechanical stokers in every-day operation is at least open to question. It is certain that before deciding to install any particular one, the purchaser should know just what fuel he wants to use, what its peculiarities are, and how it is likely to act in the furnace under consideration. If too poor in quality it may be impossible to burn it on a chain grate, while if the ash fuses and clinkers badly, it may be totally unadapted to other types.

ANNUAL CONVENTION OF THE AMERICAN RAILWAY ENGINEERING AND MAINTENANCE-OF-WAY ASSOCIATION.

The fourth annual convention was held at the Auditorium Hotel, Chicago, on March 17, 18 and 19. The President, Mr. Geo. W. Kittredge (Ch. Engr., C., C., C. & St. L. Ry.), was in the chair, and there were about 130 members present. It was the most largely attended and, all things considered, probably the most successful of any annual meeting thus far held.

It was apparent from the character of the proceedings that the Association has reached a rather critical point in its affairs. Great efforts had been made to have the committee reports sent in some time before the convention, so that they might be printed and distributed several weeks in advance, but this was only done with a few reports. Unfortunately no date limit for the acceptance of reports was made, so that there was a recurrence of the usual experience of a mass of matter rushed through the printer's hands in the few days preceding the meeting. These belated reports were of course in the hands of the members too short a time to permit any careful study. Of 15 committees, 13 had printed reports, one made a verbal report of progress, and one made no report at all. Of the 14 reports, six only were considered (including the verbal report), and four of these occupied about 90% of the time. The remainder were, by a vote at the close of the meeting, accepted as progress reports. These will be printed as such in the Proceedings, accompanied by a note to the effect that they have not been discussed.

An active discussion in regard to the future plans of procedure took place on the third day of the convention, but may be recorded here in connection with the above remarks. The retiring President, Mr. Geo. W. Kittredge (Ch. Engr., C., C., C. & St. L. Ry.), pointed out that it was evident from the experience of the meeting that some new plan must be followed in future. It is impossible to digest or act upon such a large number of reports in the limited time available. It had been intended to have all reports distributed long enough in advance of the meeting to give members opportunity to consider them, but for various reasons it had been impracticable to do more than make a beginning this year. It was hoped, however, that progress would be made in that direction, so that in future the reports could be widely discussed by written communications, and only the conclusions or recommendations of the reports taken up for action at the annual meeting. Mr. W. G. Berg (Ch. Engr., Lehigh Valley R. R.) thought it would be advisable to make a rule that no reports should be considered that have not been in the hands of the members for six weeks before the meeting.

Mr. W. C. Cushing (Ch. Engr., Penn. Lines) advocated curtailing the scope of the reports and consolidating some of the committees so as to reduce their number. Thus the committee on Masonry presented three sets of complete specifications, in addition to other matter, and any one of these would have been sufficient for consideration by the committee and the convention, leaving more time for other reports. Then the three committees on Track, Ties and Ballasting might well be consolidated, as also the two committees on Rules and Accounts. He suggested that only half of the committees should report each year, but this idea met with general disapproval.

Mr. T. B. Berry (Ch. Engr. Un. Pac. Ry.) suggested frequent changes in the committees, in order to give a larger proportion of the membership the opportunity and experience of committee work. Mr. E. E. R. Tratman (Engineering News) advised that some steps be taken to encourage the contribution of written discussions. Mr. Berg suggested the appointment of an editing committee to examine the reports in order to provide against different committees reporting upon the same subjects. Various other remarks and suggestions were made, all of which will be considered by the new Board of Direction.

The first meeting was called to order about 9.45 a. m. on March 17, when the President presented a very brief address, simply outlining the affairs and progress of the Association, and referring to the death of one of its founders, Mr. Augustus Torrey. The reports of the Secretary and Treasurer up to March 9, 1903, were then presented, and may be summarized as follows:

Total receipts since organization		$19,758
Total expenditures since organization		15,975
Balance, cash on hand		3,783
Receipts during past year		$6,553
Expenditures during past year		5,152
Balance to credit		1,401
Total number of members enrolled		477
Membership at last annual meeting	466	
Members admitted during the year	51	464
Members deceased during the year	3	
Members resigned during the year	7	10
Membership at date of report		454

The losses by death were as follows: Augustus Torrey, Ch. Engr., Mich. Cen. R. R. (a Director and first chairman of the preliminary organization of the association); E. A. Kellogg, Asst. Supt., C. & N. W. Ry.; George Montague, Supt. B. & B., Sonora Ry.

All of the reports presented are separately abstracted in this and our preceding issues, and the present report of the proceedings deals more particularly with the discussions.

ROADWAY.

This was the first report taken up, and its discussion lasted during two entire sessions, and even then was not exhausted. In justice to the other reports, however, it was decided that the discussion should then be closed, and that the remainder of the report should be accepted as a progress report. The first item discussed was the unit of measurement for clearing and grubbing, which the committee recommended should be "a square of 100 ft. square." Mr. W. S. Dawley (Ch. Engr. C. & E. I. Ry.) used 100 ft. square for clearing and 10 ft. square for grubbing, and this distinction was proposed as an amendment, but was voted down. The next point was the classification of excavated material. The report recommended three classes: solid rock, loose rock and common excavation. Two and four classes were also suggested, with various nomenclature. The former would be simply rock and earth, but Mr. T. J. Sullivan (Div. Engr., Can. Pac. Ry.) thought this would be too indefinite in regard to boulder gravel and cemented gravel. In one case a material which cost only 23 cts. per cu. yd. on a three-classification road, cost 30 cts. on a two-classification road in the same district. Mr. Hunter McDonald (Ch. Engr., N. C. & St. L. Ry.) proposed the use of the terms ("hard, medium and soft excavation," but this was voted down as were other suggestions. The three-fold classification was adopted, but the conclusion was finally amended, however, to conform to certain changes made in the specifications included in the report.

The recommendation that "profiles be made complete in regard to distribution of material, in order to obviate necessity for overhaul measurements," called forth a brisk discussion. On one hand, several members considered that it would be impossible to do this, as no matter how carefully a profile is made there will always be changes made during construction. It is therefore better to measure up the quantity after the

General Results of Tests of Mechanical Stokers.

Items.	Kind of stoker—Sloping grate.		Chain grate	
Grate surface, sq. ft.	96		65.6	
Water heating surface, sq. ft.	5,778		3,019	
Ratio of water heating surface to grate surface	60 to 1		46 to 1	
Kind of coal used	Schlecht lump.		Besser slack.	
Date of trial	July 22-23, '01.	Aug. 29, '02.	May 24, 1902.	May 26, 1902.
Duration of trial, hours	24.5	12.083	8	8
Weight of coal as fired, lbs.	66,800	55,000	15,600	9,393
Moisture in coal, %	2.4	4.68	2.9	2.5
Weight of dry coal consumed, lbs.	65,197	52,998	15,148	9,158
Ash and refuse, lbs.	22,420	19,262	1,515	1,720
Ash and refuse in dry coal, %	34.4	36.3	10	18.8
Water fed to boiler, lbs.	354,570	217,730	99,130	53,230
Water actually evap., corrected for quality of steam lbs.	347,480	216,315	98,238	52,633
Equivalent evaporation from and at 212° F., lbs.	401,300	263,214	119,750	64,057
Hourly quantities:				
Dry coal consumed per hour, lbs.	2,661	4,386	1,894	1,145
Dry coal per sq. ft. of grate surface per hour, lbs.	27.7	45.7	28.87	17.45
Water evap. per hr., corrected for quality steam, lbs.	14,183	17,902	12,280	6,579
Equivalent evap. per hr. from and at 212° F., lbs.	16,380	21,784	14,969	8,007
Equivalent evap. per hr., from and at 212° F., per sq. ft. of water heating surface, lbs.	2.835	3.770	4.958	2.652
Average pressures, temperatures, etc.:				
Steam pressure by gage, lbs. per sq. in.	152.4	145.9	125.1	122.1
Temperature of external air, ° F.	79	58.3	63	83
" " feed water entering boiler, ° F.	115.3	51.1	46.5	48.6
" " escaping gases from boiler, ° F.	No. 9—497	515	...	451
	" 10—551	457		
Force of draft bet. damper and boiler, ins. of water	0.10	0.30	0.68	0.56
Percentage of moisture in steam, %	2.0*	0.65	0.90	1.12
Horse-power developed	475	631	433.9	232.1
Rated horse-power (10 sq. ft. per HP.)	578	578	300	300
Percentage of rated horse-power developed, %	82	109	144.6	77.4
Economic Results: Water apparently evaporated under actual conditions per lb. of coal as fired, lbs.	5.308	3.916	6.354	5.667
Equivalent evap., from and at 212° F., per lb. of coal as fired, lbs.	6.008	4,734	7.676	6.820
Equivalent evaporation, from and at 212° F., per lb. dry coal, lbs.	6.155	4.966	7.905	6.995
Equivalent evaporation, from and at 212° F., per lb. of combustible, lbs.	9.381	7.802	8.784	8.608
Proximate analysis of coal: Fixed carbon, %	43.2	45.0	48.0	48.0
Volatile matter, %	22.1	26.4	39.8	38.0
Moisture, %	2.4	4.7	2.9	2.5
Ash, %	32.3	23.9	9.3	11.5
Analysis of ash and refuse: Carbon, %	29.7	33.2	42.5	42.2
Efficiency: Calorific value, dry coal per lb., B.T.U.	10,210†	10,420‡	13,010‡	12,370‡
Calorific value, combustible per lb., B. T. U.	15,260†	13,900‡	14,390‡	14,030‡
Of boiler, based on combustible, %	59.4	54.2	58.9	59.3
Of boiler, including grate, based on dry coal, %	58.2	46.0	58.7	54.6

*Assumed. †Calorific value calculated from formula. ‡Calorific value by Parr calorimeter.

materially is actually moved. Mr. C. S. Churchill (Ch. Engr. N. & W. Ry.) thought it good practice to decide beforehand as far as possible, but not to leave out entirely the consideration of overhaul measurement, which was eventually adopted.

The whole of the afternoon session was devoted to a consideration, section by section, of the specifications for roadway construction, as submitted by the committee. Mr. McDonald had prepared a very careful revision of the specifications, his suggested changes being printed in heavy type. The specifications were attacked at various points, and a number of changes were introduced, the whole matter being very carefully thrashed out. At the morning session on March 18 it was voted not to continue the discussion, but to accept the remainder of the report as a report of progress. This part included specification clauses specially applicable to the revision of existing line and the widening for additional tracks. The conclusions and specifications relating to the classification of excavated material, as finally adopted, were as follows:

SPECIFICATIONS.—Solid rock shall comprise rock in solid beds or masses in its original position, which, in the judgment of the engineer may be best removed by blasting; and boulders or detached rock measuring 1 cu. yd. or over.

Loose rock shall comprise all detached masses of rock or stone of more than 1 cu. ft. and less than 1 cu. yd. in bulk; and all other rock which, in the judgment of the engineer, can be properly removed by pick and bar without blasting, although blasting may be resorted to on favorable occasions in order to facilitate the work.

Common excavation shall comprise all other materials of whatever nature that do not come under the classifications of solid rock or loose rock, or under such special classification as shall be established before the award of the contract.

CONCLUSION.—A three-fold classification of materials: solid rock, loose rock and common excavation, as described in the foregoing specifications; and such additional classification of material as may be deemed necessary, such additional classification to be distinctly defined in the specification.

IRON AND STEEL STRUCTURES.

This committee also presented specifications, and a commencement was made in discussing these section by section, but so much time was consumed in discussing the requirements as to ultimate tensile strength that the remainder was adopted almost without discussion. The part of the report relating to unit strains, however, was accepted only as a progress report. For structural steel, the committee recommended an ultimate tensile strength of 60,000 lbs. per sq. in., and this was eventually adopted, but not until after a very warm debate and strong opposition, it being quite generally held that this figure represented too great a compromise with the manufacturers. Mr. Churchill (N. & W. Ry.) advocated 68,000 lbs., as with such material higher working strains can be used. Mr. Modjeski and Mr. Cushing (Pa. lines) took the same ground, the latter expressing the opinion that such compromise should not be made simply because the mills will not give a higher steel, but that a fight should be made for what is considered the best. Mr. R. Montfort (Ch. Engr., L. & N. R. R.) thought 60,000 lbs. certainly too low if the material is to be reamed, and as reaming costs only about 0.15 c. per lb., it would be better to use the higher grade steel at this slight increase in cost. Mr. C. Loweth (Engr. B. & B. C., M. & St. P. Ry.) thought 55,000 to 65,000 lbs. too low, and noted that as the committee's specifications call for the reaming of all metal over ⅝-in. thick, it would certainly be better to use a steel of higher grade.

On motion of Mr. Berg (L. V. R. R.), it was voted to adopt the committee's recommendation in favor of the use of a single grade of rolled steel, and Mr. Cushing (Pa. lines) thought this grade should be 60,000 to 70,000 lbs. Mr. H. G. Kelley (Ch. Engr., M. & St. L. Ry.) said that in purchasing steel specified to be of 55,000 to 65,000 lbs., 75% ranged between 59,500 and 62,000 lbs., showing that the mills aimed to strike an average, and he thought the Association would be safe in adopting the recommendations of the committee. Mr. R. H. Reid (Engr. B. & B. L. S. & M. S. Ry.) thought that the lower grade steel, as recommended (60,000 lbs), would stand impact better and have less liability to the spread of minute cracks. The higher steel may be better for very large bridges, but the specifications are intended to be for general use. Mr. W. W. Curtis thought the variation of 10,000 lbs., as allowed by the committee, entirely too great.

Mr. J. W. Schaub pointed out that the high reputation of British steel bridges is due to the use of a very superior ore, low in phosphorus, enables the acid open-hearth Siemens-Martin process to be used, and a material of 60,000 to 70,000 lbs. ultimate strength produced. On the European continent, however, with inferior ores, the basic Bessemer process is generally employed for bridge steel, producing a metal of 55,000 to 65,000 lbs. ultimate strength. In the United States the conditions are similar to those of the continent, and a basic steel of the same strength is best adapted to the process of manufacture. There is no question, however, that the higher grade steel is the better for bridge work, if it can be produced under commercial conditions. He referred to the action of the committee in omitting all consideration of elastic limit, since this shows many features which are very desirable to obtain. In fact he thought that in a few years the elastic limit will be used and the ultimate strength ignored, as is already the case with wire manufacturers.

On the part of the committee, Mr. C. C. Schneider (Am. Bridge Co.) said that for basic open-hearth steel (which is the most generally used for structural work), the best grade is from 58,000 to 60,000 lbs. A great number of the leading railways (including the Pennsylvania, the N. Y. Central, the B. & O., etc.) and railways representing a majority of the total mileage of the country use 60,000-lb. steel. This being the case, why specify a higher steel? Mr. T. L. Condron thought the 60,000-lb. steel a happy mean between undesirable soft steel and hard steel, which gives trouble from cracked angles and beams. He explained that the elastic limit is not a commercial matter, but a matter for scientific determination, and with the present rapidity of output at the mills it is not practicable to take the time for its determination. The committee therefore omitted the mention of elastic limit altogether, but he thought that later on, when the elastic limit is specified, it should be determined by an extensometer with autographic record. The measurement by dividers is too crude a method, and the existing autographic devices of recording tests are imperfect and consume too much time in their application. The yield point as determined by the drop of the beam is very indefinite, owing to the test piece slipping in the grips, and for other reasons. The committee therefore simply requires that the yield point shall be recorded in the test reports, without specifying what this point shall be, and he thought these records would show great variation in relation to the strength of the material.

RAILS.

A verbal report of progress was made by Mr. W. R. Webster. As a result of objections made by manufacturers to the drop test required by the specifications presented at the last meeting, the specifications have been modified to require a drop test for only one heat out of five, instead of for every heat. He also remarked that the manufacturers are very desirous of having the matter of standard drilling for rail joints taken up, and a resolution was adopted directing the committee to make this a subject of investigation for its report at the next meeting.

SIGNALING AND INTERLOCKING.

The principal discussion turned upon the recommendation in regard to train order signals, and there was a warm discussion over certain phrases relating to train orders. The President, Mr. Kittredge (C., C., C. & St. L. Ry.), pointed out that this was a matter rather outside the scope of maintenance-of-way, and it was voted to strike out the objectionable sentences. The committee had unfortunately mixed up its recommendations with descriptive matter, so that in some cases it was difficult to ascertain what was recommended and what was described. This accounted for much of the discussion, and the committee did not seem willing to make any changes in phraseology until these were enforced by direct vote. The use of flags and hand lamps for train-order signals was "recognized," but not recommended. The recommendation, as amended by the meeting, covered a fixed train-order signal connecting of a semaphore arm for two indications (stop and proceed), having a sweep of 90° from the horizontal, and with an arm casting arranged on the continuous light principle. This is in accord with the action of the American Railway Association which requires the use of a fixed signal.

YARDS AND TERMINALS.

The first part of this report related to the methods of operating the switching traffic or movements at yards and terminals, including methods of keeping car records in large yards. This portion of the report was approved. The second part discussed the subject of water and rail terminals at large ports, and in the conclusions certain approximate dimensions for freight piers were given. Mr. Berg (Ch. Engr., L. V. R. R.) thought that the conclusions should either be more general or more specific. The report mentioned a length of 600 ft. and width of 125 ft. in certain cases, but Mr. McGuigan (Gen. Supt. G. T. Ry.) said he had piers 200 ft. wide and did not think a less width should be specified. Mr. Felt (Ch. Engr., G., C. & St. F. Ry.) stated that the piers at Galveston were 1,200 to 1,400 ft. long and some of them 500 ft. wide; he thought that in the future none would be built less than 250 ft. wide. For the committee, Mr. W. G. Besler (Gen. Man., C. R. R. of N. J.) explained that it would be impracticable to present any but very approximate and general figures, but in view of the time already spent in detailed discussion and the number of reports remaining to be considered, it was voted to accept this part of the report as a progress report, giving the committee opportunity to reconsider it before the next meeting.

MASONRY.

While this report was not a long one, its discussion occupied some hours, since it included three complete specifications, in addition to other matter. The specifications for Portland cement and natural cement were discussed section by section, and several important changes were made. In the discussion of the specifications for Portland cement, Mr. E. H. Lee (Engr., C. & W. I. R. R.) thought provision should be made for sampling from cement in bulk in the bins. Mr. Berry (Ch. Engr., U. P. Ry.) did not approve of mixing the samples, as specified, and the committee accepted the change. Mr. Parkhurst (Ill. Cen. R. R.) and Mr. Loweth (C., M. & St. P. Ry.) did approve of the mixing, and on motion it was voted to retain the section as originally prepared, although the committee members opposed the resolution. As to the specified fineness of 94% passing a No. 100 sieve, Mr. Storey (Ch. Engr., A., T. & S. F. Ry.) found it difficult to get anything higher than 90%. Mr. Berry (U. P. Ry.) and Mr. Loweth (C. M. & St. P. Ry.) have been using cement of 90 to 92%, and find it quite satisfactory. Mr. Breckenridge (C., B. & Q. Ry.) requires 94% fineness, and has no difficulty in obtaining it. A. W. Kittredge (C., C. & St. L. Ry.) thought there was no doubt that 94% was best, but it involves commercial questions. In one case manufacturers bid 15 cts. per barrel more for cement of 95% fineness than for cement of 92% fineness, as they did not think it would pay them to carry on the fine grinding without this additional price. Mr. Kelley (M. & St. L. Ry.) called attention to the fact that the committee recommended the Vicat apparatus for testing the value of setting as being more satisfactory than the Gilmore needle. Mr. C. S. Churchill (N. & W. Ry.) expressed surprise at the omission of the sand test. The committee stated as its reason the difficulty of getting proper sand, but he found no such difficulty. The test is of the greatest importance, as it will show how the cement will behave when mixed with sand, which is the condition in which it will actually be used.

At the extra session on March 19 the specifications for natural cement were taken up in the same way, the first change being that the degree of fineness was raised from 80% to 85% on a No. 100 standard sieve. Mr. Churchill (N. & W. Ry.) again referred to the sand test, and also spoke of Lehigh cements which take a final set in 20 minutes, but Mr. Kittredge thought any cement taking a final set in less than 30 minutes would be dangerous, as there would hardly be time to set it in place before setting. Mr. Kelley (M. & St. L. Ry.) said that the Baltimore & Ohio

R. R. specifies 45 minutes to 3 hours for final set, as against 30 minutes to 4 hours, as specified by the committee. On motion of Mr. Loweth, the minimum final set was raised from 30 minutes to 45 minutes, the initial set remaining at not less than 20 minutes. No boiling test is specified for natural cement, the committee not considering it advisable for such cement. Mr. Kittredge (C., C., C. & St. L. Ry.) said that in his specifications he limited the rise in temperature during the manipulation of the test. This is essential on account of the rapidity with which cement is sometimes put out on the market and into the work. The committee was eventually instructed to investigate and report upon sand tests and temperature tests for both Portland and natural cements.

There was not time to discuss the concrete specifications in detail, but attention was called to the following requirement as to consistency:

> The concrete shall be of such consistency that when dumped in place it will not require tamping; it shall be spaded down and tamped sufficiently to level off and will then quake freely like jelly, and be wet enough on top to require the use of rubber boots by the workmen.

Mr. Kelley (M. & St. L. Ry.) pointed out that it was only intended that the top should be so wet that the men's feet would sink into it. If too wet the mortar will tend to separate from the stone, and such concrete will not "quake." Mr. Kittredge (C., C., C. & St. L. Ry.) referred to the 16-story concrete building now being erected at Cincinnati, in which the concrete is so wet that wheelbarrows can only be partly filled, as the stuff slops over with the motion of the wheelbarrow. Mr. Tratman (Engineering News) remarked, in regard to the same building, that while the concrete is entirely too wet to be tamped, it is thoroughly worked or stirred by long wooden poles and iron rods, which are thrust as deeply as possible into the mass. This is done to free any bubbles of entrained air and to ensure close contact of the concrete with the steel bars and rods. In regard to placing concrete in winter, Mr. Kittredge referred to a building where the laying of a floor was followed by a sudden drop in temperature. Owing to subsequent changes in the design, this floor was broken down, and pieces of concrete showed distinctly all through them the crystals resulting from freezing of the concrete. The concrete was very wet and no salt was used, but he thought it a strong argument against laying concrete in winter.

BUSINESS MEETING.

This concluded the technical part of the proceedings, it being voted to accept all the unconsidered reports as progress reports, as already stated. On motion of Mr. McNab (G. T. Ry.), the Association passed a vote of sympathy for the Secretary, Mr. L. C. Fritch, who has been seriously ill for several months, but whose recovery is now hoped for. It was also voted unanimously to appoint as Secretary pro tem. his brother, Mr. E. H. Fritch, who has been carrying on the work very efficiently. The remainder of the business meeting was devoted to a discussion of the affairs of the Associationt, which discussion has already been noted at the opening of this article. After the election of officers the convention adjourned.

ENTERTAINMENT.

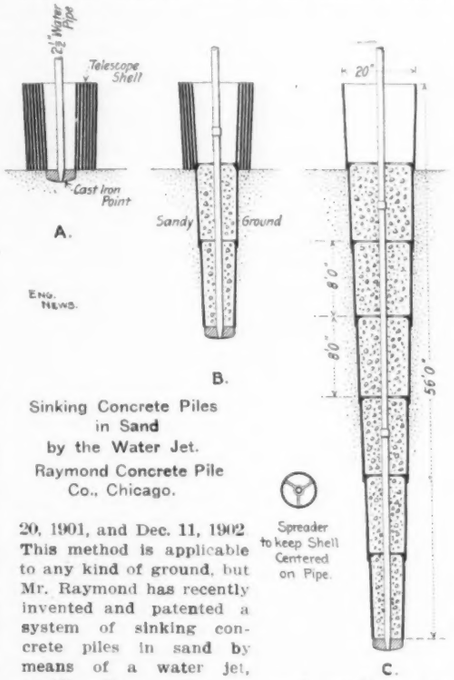
In place of the ordinary formal banquet, there was an informal one-course beefsteak dinner at 6.30 p. m. on the first evening, followed by a smoker. There was a very large attendance, about 200 members and guests being present. After the dinner the members mingled socially for general conversation, the opportunity for sociability and for making acquaintances being much greater than at the more formal "banquet."

OFFICERS.

The election of officers resulted as follows: President, Hunter McDonald, Chief Engineer, Nashville, Chattanooga & St. Louis Ry.; First Vice-President, H. G. Kelley, Chief Engineer, Minneapolis & St. Louis Ry.; Second Vice-President, James Dun, Chief Engineer, Atchison, Topeka & Santa Fe Ry. System; Mr. A. W. Sullivan, Assistant Second Vice President of the Illinois Central R. R., and Mr. G. W. Kittredge, Chief Engineer of the Cleveland, Cincinnati, Chicago & St. Louis Ry., were elected as the new members of the Board of Direction; Treasurer, W. S. Dawley, Chief Engineer, Chicago & Eastern Illinois Ry.; Secretary, L. C. Fritch, Cincinnati, O.; Secretary pro tem., E. H. Fritch, 1562 Monadnock Block, Chicago.

CONCRETE PILES FOR SANDY GROUND.

The Raymond system of making concrete piles in place by forming a hole (with a sheet iron casing which remains when the core is withdrawn), and then filling the hole with concrete, has been described and illustrated in our issues of June 20, 1901, and Dec. 11, 1902. This method is applicable to any kind of ground, but Mr. Raymond has recently invented and patented a system of sinking concrete piles in sand by means of a water jet, avoiding the use of a core and enabling piles to be driven to greater depths, as very long cores could not well be handled.



Sinking Concrete Piles in Sand by the Water Jet.
Raymond Concrete Pile Co., Chicago.

This method is illustrated in the accompanying cut. An iron shell of the desired taper is formed of telescopic sections of sheet iron, each section being 8 ft. long, and having at its upper end projections which will engage with projections on the lower end of the next section, so as to pull the latter down. To the bottom section is attached a cast-iron point, with a ¾-in. jet hole or nozzle, to which is fitted a 2½-in. pipe. This pipe is held in position by spreaders, as shown; it remains in place in the finished pile, to which it adds lateral strength.

The operation is easily understood. With the casing assembled, as at A, the jet is started, and the first section put down; this pulls the second section, as shown at B. The sections are filled with concrete as fast as they are sunk, so that there is no collapsing of the shell. The completed pile is shown at C, but it may be of any depth and diameter required. In a test made in the Missouri River at Omaha, Neb., a pile was put down 75 ft., with only 40 lbs. water pressure for the jet.

This system is claimed to be specially adapted to bridge foundation work. It is being introduced by the Raymond Concrete Pile Co., 135 Adams St., Chicago, which company also controls the other system of concrete pile construction above referred to.

THE WATER CONSUMPTION AT LOWELL, MASS., was lower in 1902 than in any previous year since 1890, while the per capita consumption was much lower in 1902 than in 1890. The population of Lowell by the Census of 1890 was 77,696, and by the Census of 1900 it was 94,969. The estimated population in 1902 was 100,000. The total average daily consumption in 1890 was 5,373,536 gallons, and in 1902 it was 5,729,536 gallons; or 69 and 57 gallons per capita, respectively. In the 12 years, the mileage of water mains increased from 92 to 132; the number of services, from 8,732 to 10,984; and the number of meters from 1,935 to 7,129. In other words, population has increased 30%; mains, 43%; and services, 23%; but the total daily water consumption has increased only 7%, and the per capita water consumption has decreased 18%. The relative falling off in consumption is undoubtedly due very largely to the fact that the percentage of taps metered has increased from 22 in 1890 to 55% in 1902. For the figures on which this note is based we are indebted to Mr. R. J. Thomas, Superintendent of Water-Works at Lowell.

THE POSITION OF CATTLEGUARDS AT ROAD CROSSINGS.

The appointment of a special commission by the Canadian Government, under the Department of Railways and Canals, for the purpose of investigating the efficiency of railway cattleguards for road crossings has already been referred to in our columns, and the work of the Commission is still in progress. An important step which has been taken by the Commission, independent of the efficiency of cattleguards, is in recommending a change in the position of fences and cattleguards at crossings. In the accompanying cut, Fig. 1 shows the usual position of the cattleguard in relation to the fences, except that in some cases the highway fence is brought to the middle of the guard instead of to the highway end as shown. Fig. 2 shows the proposed change in the location of fence and cattleguards. The guard is placed within 4 ft. or 5 ft. of the ends of the crossing plank of the traveled way and the highway fence is brought to within 7 ft. or 8½ ft. of the center of the track and returned parallel with the track to the highway end of the guard. The advantages of this arrangement are described by the Commission as follows:

> In case of wandering animals feeding along the roadside, their attention will be directed away from the right-of-way of the railway instead of finding an opening into which their curiosity tends to lead them, as is the case under the ordinary arrangement.
>
> It reduces the length of crossing upon which animals can gather, as is their tendency in some localities. At the same time it does not impair the usefulness of the highway in the least, since the part thus fenced in is not used for travel.
>
> It will be additionally effective as a crossing signal and prevent teams under the guidance of irresponsible drivers from turning down the track. Of this there are several disastrous instances, particularly in reference to the old pit guard, as well as others.
>
> It offers no inducement for the animals to go on the right of way because there is apparently only the track, ties and ballast (protected by a guard), to the right or left, while there is the regular highway with no hindrance left open to them, with an apparent open gateway which curiosity will tend to lead them to choose.
>
> In case of cattle being met on the crossing by a train, as is frequent, the fences will act as a shelter behind which the animals will dodge, instead of, as now, making a rush for the opening which the guard is called upon to protect.

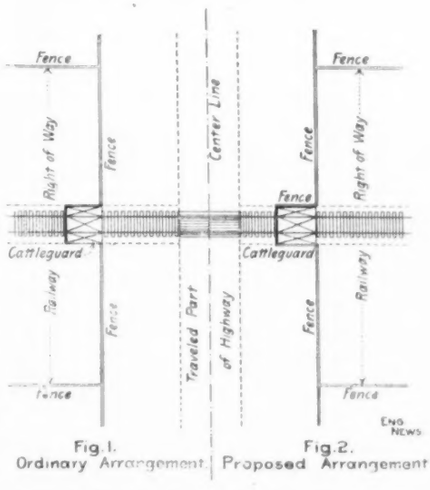


Fig. 1. Ordinary Arrangement. Fig. 2. Proposed Arrangement.

Ordinary and Proposed Arrangement of Cattle-Guards and Fences at Grade Crossings.

(The proposed arrangement is recommended by the Cattleguard Commission of the Department of Railways and Canals, Canada.)

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ADVERTISING RATES: 20 cents a line. "Want" and "For Sale" notices, special rates, see page XXIV-XXIX. New copy for standing advertisements should be received one week in advance of publication; new advertisements, Monday morning. The pages containing "Want," "For Sale" and "Proposal" advertisements are held open until Wednesday noon.

The report of the Railway Engineering Association Committee on a standard train order signal, printed in this issue, calls attention to a detail of railway operation in which radical improvement is badly needed, particularly on railways which do not use the block system, and on which consequently the correct handling of train orders is the only reliance to keep trains from collision. On a considerable number of American railways the train order signal is nothing but a flag or lantern stuck up at any place in front of the station that suits the station master's convenience. This is not merely slipshod railroading; it is trifling with human life. There is no railway with traffic enough to use train orders at all which is so poor that it cannot afford a fixed signal to instruct its engine runners approaching stations whether they are to proceed or stop for orders.

At a meeting of the Pacific Coast Railway Club on Feb. 21 a very interesting discussion took place over the question whether a train order semaphore should be held at "normal clear" or "normal hold." The latter is the practice of the Southern Pacific Co. Under its rules an engineer approaching a station where he is not scheduled to stop and seeing the station semaphore at "hold" gives four short blasts of his whistle. If the semaphore moves to "clear" he proceeds. He is obliged to stop, however, unless he actually sees the board move from "hold" to "clear." It will be seen that this corresponds to block signaling practice, where the "normal danger" position is the universal rule with manually operated signals.

In the Pacific Coast Railway Club discussion, the concensus of opinion was strongly in favor of the "normal hold" system. It was, however, pointed out that the question has two sides, and there is an ever-present possibility that the station operator who gets in the habit of pulling the semaphore to clear when he hears a train give the station whistle will some day pull it to clear for a train for which he has orders.

A striking feature of the whole discussion is the light which it sheds on the dangers of the train order system of railway operation, even when surrounded with the best safeguards. We all know, though we do not often stop to think, that these important orders on which the safety of train loads of passengers depend are handled by station masters who have a multitude of other distracting duties to perform. We read in this discussion of the chances that operators may cover up train orders with other papers and forget that they have them; they may clear the wrong semaphore and thus fail to hold a train for which they have an order; they may give a train crew one order and forget to give a second, as happened in the serious accident on the Southern Pacific on Jan. 28 last.

As one of the contributors to the discussion very truly remarked, "Men always have forgotten and always will forget." The train order system requires for its success that men shall not forget; that the train dispatchers shall not forget and give two trains a right to the same track; that the station operator shall not forget to deliver the message he receives, at the right time and in the right way, and that the engineer and conductor shall not forget to execute the orders which they receive. In all these cases mechanical appliances are available as aids to the memory to reduce the risk of forgetfulness and disaster, and these ought by all means to be made use of wherever the train order system is to continue in use.

It is easy—on paper—to burn coal with a high degree of economy and freedom from smoke; but to carry it out in daily practice with actual coal and actual firemen is a totally different thing. We record, in this issue, some interesting tests of mechanical stokers recently made at a large boiler plant, which well illustrates the difficulties not infrequently experienced by those responsible for the proper use of coal. In the particular case in question one difficulty met with was the accumulation of clinkers, a trouble not all all uncommon in connection with devices which aim to secure more perfect combustion by increasing the temperature of the furnace. We hear a great deal in print of the loss of furnace efficiency through smoke, through insufficient air supply, through unburned gases, through loss of heat up the chimney, etc.; but we suspect that in actual daily practice in the average boiler room the thing which gives more trouble to the fire-room force than anything else is the formation of clinker. Waste of coal is no sin in the Superintendent's eye compared with letting the steam pressure drop; and to keep the grates clear of clinker a large amount of unburned coal has often to be sacrificed.

The city council of Norfolk, Va., is still dilly-dallying over the question of water waste restriction as against a new 30-in. force main. For three years Mr. W. T. Brooke, City Engineer, has been urging the adoption of meters to prevent the necessity for a second main. The consumption and waste is now 103 gallons per capita, but deducting the population not supplied with city water the figure would be considerably higher.

Some members of the city council are opposed to meters, and some maintain that much of the indicated pumpage is really slippage, and that leaks in the old force main account for still more of the alleged waste. The use of the pitometer to aid in settling these contested points has been proposed. While it is well worth while to use the pitometer for the purposes named, it should be understood that it will have no permanent effect upon the prevention of either waste or leaks, and must be supplemented by meters if the water consumption is to be kept at a reasonable figure, and the cost of the water service equitably divided among the several consumers. A permanent meter at the pumping station, and district meters in the city, would serve as a check on the pump records, on leakage through the force main, and on waste and leakage in the different sections of the city. Meters on private services, beginning first with the larger and more wasteful consumers, and extending to other water takers as experience warranted would finally afford a complete check on the efficiency of the pumps and distributing mains, on the one hand, and on the wastefulness and carelessness of consumers, on the other. Prior to the adoption of so systematic a plan, and even in connection with it, the pitometer might be used to good advantage.

THE MISSISSIPPI FLOOD AND THE LEVEE SYSTEM.

The prevailing flood in the lower Mississippi gives rise to the usual crop of newspaper criticisms of the levee system and the engineers responsible for it. These criticisms are made usually in good faith, but in entire ignorance of the actual problems which confront the engineers.

We find a specimen of these criticisms on the editorial page of the "New York Times" of March 23 and print it in part, as follows:

> There is more excuse this year than usual for the failure of the Mississippi levees to serve the purpose for which they were erected, since the river has risen above all its recorded high-water marks, and yet one cannot help feeling that there is cause for humiliation as well as for sorrow in the too familiar stories of widespread disaster that are now coming from so many parts of the great delta. Year after year enormous sums are expended in building and rebuilding these levees, and year after year they prove inadequate when they are tested by the inevitable spring floods. Of course the problem of restraining a river of such a size and with such a bed as the Mississippi is one of the utmost difficulty, and not equaled anywhere else in the world, perhaps; but American engineers are not accustomed to admit the existence of physical impossibilities, and they have been at work on this particular problem, now, for a long while, with results by no means impressive—except in their expense accounts. How long will it be before they admit that the best levees they can make are inadequate, and proceed with the devising of a system altogether different for attaining the desired end? We surely ought to be able, somehow, to avoid an annual tax of really frightful dimensions.

It would be difficult to crowd into the above space a greater amount of misinformation than is there conveyed.

The writer at the outset generously gives the engineers a hole to crawl out of by suggesting that the river this year has risen above its highest recorded stage. He is evidently wholly unaware of the fact that the levee engineers have known for many years that the next Mississippi flood would certainly exceed the highest stage yet recorded, at least along the channel in Tennessee and northern Mississippi, on account of the closing of the St. Francis Basin in Arkansas and Missouri, into which the Mississippi has formerly overflowed at every great flood.

It will naturally be said that if this was well known to the engineers, why were not the levees raised to a point well above the highest level of water to be expected? In answer to this it must be explained that in the building of levees it is not a theory but a condition that confronts the engineer. He knows all about the theory of earth embankments, and not only the theory, but the practical method of building them high enough and strong enough to withstand any flood that the "Father of Waters" could produce; but the practical condition that confronts him is just so many dollars of available funds to be expended, and his duty is to make these dollars do the most in the way of protecting a certain number of miles of river front from overflow.

But, says the newspaper critic, why build levees in so inadequate a fashion? Would it not be far cheaper and better in the long run to build the levees once and for all, high enough and strong enough to withstand the highest floods?

Perhaps it would, but here again we must take conditions as we find them. The money for building these levees is furnished, except for small contributions from the United States treasury, by local taxation of the districts protected by the levees. These local taxpayers very naturally prefer to keep their tax burdens within the limits of what their income from their crops of corn and cotton and other products will meet. They are raising and strengthening the levees year by year as their means permit; and are in many respects better judges of what is for their interests than the newspaper critics a thousand miles away.

It will not do to be too certain, either, that a levee system high enough and strong enough to keep out any flood would be enough better than

the present system to be worth its greater cost, purely as an economic proposition.

It is not true, as the "Times" says, that "year after year the levees prove inadequate when they are tested by the inevitable spring floods." High water indeed comes every year; but a flood that threatens the levees comes only once in from four to nine years. The last great flood previous to the present one was in 1897. Can our contemporary understand that a levee system which keeps out floods five or six years out of seven may be well worth all it costs, even though it be overtopped in some places, in the seventh year? The "Times" is very far from the mark when it says of the work of the levee engineers that it is "by no means impressive except in their expense accounts." As a matter of fact, it would be difficult to find a great engineering work which is yielding larger returns on the expenditure than the existing levees on the Lower Mississippi.

Still another error in the above quotation from the "Times" is the assumption that the present overflow involves "widespread disaster" and "an annual tax of really frightful dimensions." In contrast with this we may quote from the late Major Wm. Starling's admirable monograph on "The Floods of the Mississippi River," in which he remarks that "the damage done by overflows in the Mississippi is generally much overrated."

As we have shown above, the present levee system is sufficient to protect from all but such exceptional floods as that of the present year, and even in the present year, when the actual losses are computed, they will probably, from present prospects, be found far less than sensational press dispatches would lead one to believe.

In thus defending the levee system and the engineers who have carried it forward to its present stage, we do not by any means claim that it is perfect in its present condition or that such overflows as those of the present year are likely to be a permanent condition in the lower Mississippi valley. The levee system is admittedly incomplete. It is being gradually added to year by year as the money for the work becomes available, and eventually the entire alluvial region will be protected by embankments high enough and strong enough to keep out the greatest floods.

Finally our contemporary appears to think that there must be some other means than the levee system of controlling these floods, and it plaintively inquires how long it will be before the engineers "abandon levees as inadequate and adopt some system altogether different." It reflects a popular idea that there is some other and better method of flood protection, and that only the ignorance or conservatism of the engineers in charge of the Mississippi improvement prevents it from being adopted.

The idea is strongly rooted in the popular mind that reservoir construction on the head waters is the proper remedy for these great floods. A recent editorial which came to our attention dealt in flowery language with the time "when these destructive wastes of water shall be stored and utilized for irrigation and other beneficent purposes." No such illusions are likely to affect the man who actually sees the lower Mississippi "on the rampage." The maximum volume of flow in the Mississippi below the mouths of the Arkansas and White rivers in the flood of 1897 was set at 1,740,000 cu. ft. per second by Major Starling. Comparing this flow with the volume of water which will be stored by the new Croton dam, nearly the largest artificial reservoir of water ever created, we find that the Mississippi flow would fill the reservoir behind that great dam in less than 41 minutes. Even if there were in that part of the Mississippi valley from which its floods come, geological and topographical conditions suited to the construction of immense reservoirs (which is not the case), the cost of their construction would make the task wholly impracticable. Using a similar comparison, with the cost of the new Croton dam as a standard, Major Starling showed, in his book before referred to, that the reservoir construction to lower the Mississippi flood heights a single foot—if reservoirs could be built as advantageously as in the Croton valley—would cost fourteen times as much as the cost of raising the whole levee system one foot in height.

LETTERS TO THE EDITOR.

Co-Operation Between Engineering Societies.

Sir: It gave the writer great pleasure to note the editorial remarks in your last issue on the co-operation of engineering societies. I would like, however, to call your attention to the fact that during a meeting of the members of the American Society of Mechanical Engineers of the vicinity of Saratoga, assembled at Albany on March 6, 1903, a motion was made and a committee appointed to investigate the feasibility of a permanent organization of local members of the American Society of Mechanical Engineers, and also of having a local general engineering organization, including chapters of all the various national engineering societies. Your expressed encouraging words will help a great deal towards the culminating success of the movement.

Very truly yours,
A. M. Feldman, M. Am. Soc. M. E.

Albany, N. Y., March 20, 1903.

Cost of Electric Street Light at Columbus, Ga.

Sir: In your issue of March 19 there is an article on "Street Lighting Conditions in New York City and a Proposed Municipal Plant," in which is a table of "Prices Paid for Electric Street Lights in Various Cities."

In this connection I think it of interest to note that the city of Columbus, Ga., secures its street lights from a private corporation for $50 per light per year, 2,000 c.p. We have been getting this rate for the past two years, are now in the third year, and have recently renewed the contract for the fourth year at the same rate.

The explanation of this price I think is that the lights are generated at one of the several water power plants located on the Chattahoochee River at this place. Domestic and commercial light and power can, and is, also obtained at proportionately low rates.

Yours very truly,
Robt. L. Johnson.

Columbus, Ga., March 21, 1903.

The Profits of the Municipal Street Lighting Plant at Detroit, Mich.

Sir: I note on p. 212 of your issue of March 5, a reference to my report on "Municipal Ownership of the Detroit Electric Lighting Plant," as submitted to the Convention on Municipal Ownership, recently held under the auspices of the New York Reform Club. Your article states that my report showed a gain of $195,000 (we said $145,000—Ed.) for the city as compared with the acceptance of a bid for a ten-year contract made by a private company in 1893.

The above statement is in error, the summary of my report being that the net profit to the city for seven years complete operation of the plant (including a loss during the two years of preparation) over what it would have cost for light from a private company at the figures quoted at the beginning of this period, was $343,980, as compared with ten-year rates quoted; or $428,568, as compared with three-year rates quoted. I estimated a net saving to the city on the same basis for the year ending June 30, 1903, would be, as compared with ten-year rates, $144,878; or as against three-year rates, $120,712. These figures show that the public lighting plant, which has cost the city up to the beginning of the present fiscal year, $932,232, on which I allowed depreciation of $135,753, leaving a net value of $796,478 will, at the outside, by June 30, 1905, be a clear profit to the city.

Trusting you will see that this correction is made so that the statement in your paper will not conflict with my report as submitted, I remain, yours very truly,

Jos. E. Lockwood.
President Michigan Electric Co.

Detroit, Mich., March 16, 1903.

The Harbor Improvement Work at Cumberland Sound.

Sir: In your issue of March 12, 1903, in your editorial comment on the work of improving Cumberland Sound, Ga., under Captain Gillette, you state that

he has made a harbor entrance at Cumberland Sound with deeper water across the bar than any other port on the South Atlantic Coast. The depth of low tide is now over 25 ft. and it is steadily increasing without dredging.

I think you will see at once by reference to the maps and to Mr. Bacon's statement, that this statement is an error.

On page 242 at the top of the third column Mr. Bacon states that "Dredging ceased in August, 1902, when an available depth of 20 ft. at low water had been secured. . . . This depth has been increased without dredging to 21 ft. at the present date."

In the "addendum" at the bottom of the same column he states that since writing the first article "the available depth across the outer bar has been increased to 25 ft. at low water while that on the inner bar remains about the same," which from his previous statement was about 21 ft. Of course, the 25 ft. depth at the outer bar is of no practical benefit until the inner bar has the same depth. By referring to the map of the survey of Oct. 8-13, 1902, you will see that the shoalest soundings on the inner bar are 21.3, 21.7, 21.8 and 21.3 ft.; whereas on the map of the survey of December, 1902, the shoalest soundings on the same part of the bar are 20.6 and 20.8 ft., indicating a very slight shoaling.

As an example of rapid deepening by jetty work and dredging combined I would like to mention the jetty work of Charleston, S. C. I was employed on the jetties there as inspector for about five years and during the last continuous contract, which was completed in considerably less than the allowed time of three years, the depth was increased from a narrow, unnavigable and winding channel of about 12 ft. to a long straight channel of 20 ft. depth where dredging had been carried on, and another channel of the same depth branching off from this at about midway of the bar in which a dredge had not been used at all.

This latter channel widened and deepened so rapidly of its own accord that the dredge was finally shifted to it, and it is now the regular entrance channel with a depth greater than that at Cumberland Sound.

Very truly yours,
Walter M. Smith,
Assoc. M. Am. Soc. C. E.

U. S. Engineer Office, Portland Me., March 16, 1903.

(Our comment, which is quoted above, was made with entire knowledge of the existence of the inner shoal a mile inside the entrance, where the depth is 4 to 5 ft. less than on the outer bar. While the additional depth on the outer bar is of no present benefit until the shoal inside is deepened, it is of great importance as showing the success of the work of improvement. The inner shoal is comparatively unimportant, for once dredged it is not likely to constantly reform. The case is entirely different on the bar at the mouth of the jetties, where the inner and outer forces meet. Maintenance of channel depth across the outer bar is a difficulty with which harbor engineers constantly have to contend. Hence, we believe we are correct in emphasizing the depth across the outer bar as showing the remarkable success attained at Cumberland Sound, notwithstanding the shoal of less depth a mile inside.

As for our statement that Cumberland Sound has now the deepest water *on the outer bar* of any part on the South Atlantic coast, our understanding is that the depth is about the same on the Charleston outer bar at mean low water (25 ft.), but there is about a foot more tide at Cumberland Sound.—Ed.)

Some Practical Hints on Hand and Power Drilling in Mine Stopes.

Sir: In your "Hints on Power Drilling in Mine Stopes" which appeared in your issue of March 5, the reasons which you attribute to mine superintendents for abandoning machine drilling for hand drilling in stopes may apply to those superintendents who, through weakness or lack of confidence in themselves, permit their employees to dictate to them what they shall do and how they should do it, but I do not think any such lack of discipline exists under a manager or superintendent who has ideas of his own and enough self-confidence and force to put them into execution. A great deal of information can be obtained from expert laborers; this should be carefully weighed and used accordingly.

There are some deposits of ore which cannot be mined so economically by machine drilling as they can by hand drilling, and there are other deposits which cannot be mined with any profit at all when machines are employed, yet they can be made to yield a satisfactory return when worked by hand. Machine drilled holes cannot be so advantageously placed in any form of deposit as can holes bored by hand drilling. Some "pay streaks" are so narrow that it would be impossible to win the ore with a machine without breaking an amount of waste which it would be unnecessary to break if hand drilling were adopted. Even in large bodies of ore, especially those occurring in faults where the ore is associated with more or less worthless fault material, it is advisable to break the ore and waste separately, thus permitting underground sorting and stowing of the waste. Machine drills can be used to advantage in stoping when it is necessary or permissible to drill the holes to a considerable depth in order to break a large tonnage of low grade milling ore or of ore of uniform grade containing but little waste. A machine is an awkward thing to handle in a stope, and much time and labor will be saved by hand drilling where only one hole or a few "pop" shots are to be bored. In loose, heavy ground the concussion due to the firing of a number of deeply drilled holes may be so great as to cause the roof to cave and break down the timbers, and in some cases result in the complete loss of the stope. In ground of this character it is necessary to keep the timbering close to the working face, and the holes had better be bored by hand, as the amount of ground broken can be better regulated, and the danger of exposing too much unsupported rock be obviated.

When economy is determined by the cost per foot of driving a heading, hand drilling proves to be more eco-

nomical than machine drilling except in very hard rock. The advantage gained by using machines is in feet per month, or time, which is the essence of most contracts, and a controlling element in the development of a large property.

I do not think any competent machine drill operator would use a tripod where it would be possible to use a bar. The tripod does not hold the machine so firmly as the bar holds it, and at one setting a greater number of holes can be placed to better advantage by using the bar. The tripod is a clumsy affair, difficult to set up in a stope, and it places the operator in a strained position, especially when drilling "uppers" in overhand stoping.

My experience in the use of compressed air for drilling rock has led me to favor the use of small machines and high pressures. For stoping and making raises I use a 2-in. machine, weight unmounted, 95 lbs., worked under a pressure of 110 lbs.; I would carry a higher pressure if the plant would bear it. This machine can be mounted and operated by one man. In making raises, broken 4 ft. 4 ins. wide by 7 ft. 10 ins. long, I employ two men with two machines mounted on a 3-in. bar 8 ft. long; a bar of this length will spring some but not enough to require bracing. The raise is timbered with 8-in. framed sets, one compartment being used for ore and waste, and the other for men and timbers. The machine men work on a platform supported on stulls above the sets; when they have attained a height of about 20 ft. above the sets the timber gang builds the sets up as near to them as possible. When a "round" of holes has been drilled the machines and tools are placed in the manway, which is then covered with heavy plank or stulls; an opening left in the partition of the top panel furnishes an exit from the ore chute to the manway. By working in this manner the timber gang does not interfere with the drill men, who continue at work while the timbers are being placed.

For driving ordinary levels I use 2¾-in. machines, and for small tunnels I use 3-in. machines. I have tried the large machines in vertical and nearly vertical raises, and have had good men "throw up their jobs" on account of the severe labor of setting up the machines.

The limit to which the air should be compressed for use in rock drills must be determined for each particular case, depending on the hardness of the rock and the speed to be attained. In driving the Newhouse tunnel, at Idaho Springs, Colo., a pressure of 100 lbs. was used; the loss of energy in expanding air from this pressure to atmospheric pressure is considerable. Basing my opinion on the meager data I have been able to obtain on the subject, I am inclined to favor the use of high pressure with a return system for underground pumps, hoists, and drills when their distance from the power plant is not too great.

In the attached tables are given the sizes of drills and bits I use in the different sizes of machines. The shortest drills, or "starters," are made entirely of grooved, or cross (+) steel, and the others are made of octagonal steel with bits of cross steel 12 ins. long welded to them. When the starters become too short through use they are made into bits for the longer drills. The grooves in the cross steel afford a ready passage for the cuttings, thereby preventing the drill from becoming choked.

Sizes of drills and bits for 2-in. machines, 15-in. feed, 5-in. stroke.

Shank ⅞ × 4 ins.	Diam. of steel. in ins.	Gage of bit, in ins.	Length of drill, ft. ins.
Starter (+ steel)	1⅜ × ⅝	1¾	2 0
2d length	⅞ oct.	1⅝	3 3
3d "	"	1⅝	4 6
4th "	"	1½	5 9

Sizes of drills and bits for 2¾-in. machines, 24-in. feed, 6½-in. stroke.

Shank, 1 × 5 ins.	Diam. of steel in ins.	Gage of bit, in ins.	Length of drill, ft. ins.
Starter (+ steel)	1¾ × ⅝	2⅝	2 10
2d length	1⅛ oct.	2 7/16	4 10
3d "	1 "	2¼	6 10
4th "	1 "	2 1/16	8 10

1½ × ⅝-in. + steel used for the smaller bits.

For the 3-in. machines with 24-in. feed, 6½-in. stroke, and 1⅛ × 5-in. shank the lengths of the drills and the gages of the bits are the same as those for the 2¾-in. machines, but 1¼-in., and 1⅛-in. octagon steel, and 1½ × ⅝-in., and 1⅜ × ⅝-in. + steel is used.

J. B. Guinn,
General Manager Guinn Lead and Zinc Properties.
116 Joplin St., Joplin, Mo., March 10, 1903.

Rolling Lift Bridge at State St., Chicago, Ill.

Sir: The new Scherzer rolling lift bridge over the Chicago River at State St., which was opened to traffic on March 12, is the largest highway bridge of its kind in Chicago, and the eighth bascule bridge to be built by the Sanitary District.

The new bridge is 168 ft. 6 ins. c. to c. of bearings, has two trusses in each leaf spaced 40 ft. 6 ins. c. to c. and gives a clear channel of 140 ft. width, with 16 ft. clear head room when closed. The bridge carries a roadway 37 ft. clear and two 10-ft. sidewalks.

The foundations are of Portland cement concrete, supported on piles driven to — 55 ft. city datum (practically the water level). The piles were cut off at — 30 ft. in the piers and — 25 ft. in the abutment. The foundations were started about a foot lower and built up to + 1 city datum. The load on the piles was calculated at 12 tons per pile, that on the floor at 100 lbs. per sq. ft., that on the trusses at 87 lbs., and a wind load of 15 lbs.

The bridge is operated from either side of the river, or each leaf may be operated from the house on its respective side. The power is supplied by two 500-volt 52-HP. Westinghouse reversible street railway motors, series wound, and the current is taken from a trolley line which crosses the bridge.

There was used in the foundations 50,147 lin. ft. of piling and 4,600 yds. of concrete. The counterweight aggregate 836,543 lbs. and 1,454,067 lbs. of structural steel was used in the bridge.

The design was made by the Scherzer Rolling Lift Bridge Co. under the direction of Mr. Isham Randolph, Chief Engineer, and Mr. C. R. Dart, Bridge Engineer of the Sanitary District. Lydon & Drews, of Chicago, were the contractors for the substructure, and the American Bridge Co. was the contractor for the superstructure.

Yours truly, Wm. Artingstall.
1005 Security Building, Chicago, Ill., March 16, 1903.

Are End Stirrups an Advantage in Concrete-Steel Beams?

Sir: One would suppose from reading the article by Capt. John S. Sewell, in Engineering News, of Jan. 29 last, that it is a well established, undisputed, and incontrovertible fact that the weakest part of a concrete-steel beam is not at the center, as many of us have supposed, but at or near the ends, and that a theory clearly demonstrating this fact is much needed. Captain Sewell regrets that this important theory has not been worked out by any American investigator, or in fact by any investigator anywhere. He states that a practical man without technical training made the great discovery; that European practice is far ahead of American practice; and he hopes that the finishing touch to the correct theory may be worked out on this side of the Atlantic, etc.

After reading Captain Sewell's article quite carefully, the writer fails to discover any ground for a belief that the weakest point of a rectangular concrete-steel beam of uniform depth is at or near the ends, but he does believe that the principal reason why no engineer has been able to demonstrate the correctness of such a theory is that it is not true; he believes further that all stirrups passing around the bars and leading upwards are utterly useless; also all bends in bars except to prevent slipping.

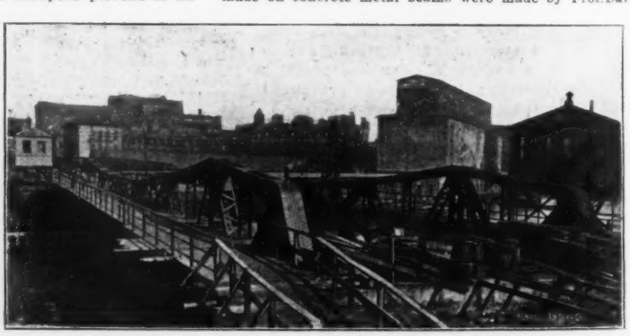
Captain Sewell gives a diagram showing lines of principal stress in a beam, and considers that such lines give the true explanation why a beam should give way at the ends instead of at the center. The writer freely admits that such lines of tension and compression exist in a beam, and that they intersect the neutral axis at angles of 45°. Captain Sewell neglected to mention, however, that the stress along each of these lines is greatest where it is horizontal, and diminishes to absolute zero at the ends where it meets and is vertical to the top or bottom of the beam. It is seen therefore that these lines of principal stress have no tendency to start a crack at either the top or bottom of a beam, and it will be generally admitted that there is not much danger of a crack starting somewhere in the interior in the neighborhood of the neutral axis. These lines of principal stress, however, as is well known, give an accumulation of horizontal stress which is a maximum where the bending moment is a maximum.

Captain Sewell gives three photographs, and some other illustrations, which he considers show clearly the truth of his desired theory, but the illustrations are unfortunate for this purpose. The photographs show concrete-steel slabs loaded uniformly in one direction, and supported by small bearings at each corner. The dimensions of the slab, distribution and amount of re-enforcement, bearing area, breaking load, mixture and age of concrete, etc., are not given, but this is not important, for if there is any way of estimating, even approximately, the strength of such a slab, the writer would be glad to learn the secret. It is presumed that these tests were made to represent something contemplated in actual practice; if so they are useful as furnishing a monumental example of bad construction. So far as can be judged by the photographs, the shearing stress at each corner of these slabs must have been six or eight times as great as it would have been in a beam supported at the ends; so we would naturally expect failure to take place at or near the ends, yet, notwithstanding the adverse conditions, the second slab appears to have actually failed at the center.

The other illustrations given by Captain Sewell are not much better suited to confirm this theory. They are T-sections presumably intended to represent thin reinforced concrete joists supporting sections of floor slabs. The average shearing stress of concrete, according to the experiments of Professor Bauschinger, is, in four weeks, about 1⅛ times the tensile strength, and in two years about 1½ times the tensile strength. As the joists support the entire dead and live load, large bars of great strength are generally embedded in the concrete near the bottom, and in close proximity to the sides of the joists. All stress in the bar must give a corresponding reaction on the concrete. The strength of the bar and the longitudinal shear on the concrete vary as the square of the diameter of the bar, while the adhesion and friction vary as the diameter only; the larger the bar, therefore, and the thinner the body of concrete in which it is embedded, the greater the danger of failure by the slipping of the bar, or by the longitudinal shearing of the concrete. If either happens, the effect is greater at the ends than at the center of the beam, particularly if the bars have sharp corners, which will tend to tear the concrete to pieces. In the examples given, the T-beams appear to be partially fixed at the ends, and the point of maximum moment may be at the end or center, so they are poor examples on which to base a theory.

Probably the most extensive series of reliable tests yet made on concrete metal beams were made by Prof. David Kirkaldy, of London, in 1876, under the direction and at the expense of Thaddeus Hyatt. The results were published by Mr. Hyatt in a book for private circulation, which is now out of print. Fifty tests were made, of which 48 were on concrete-iron beams, and 2 on concrete beams; 28 of these tests are illustrated, and every one of them broke at center; the balance of the tests are not illustrated, and the book does not state how they failed, and it does not matter much as they are not of such construction as would be used at this time. Tests were made with round bars near bottom, also near both top and bottom; some with nuts at ends; some riveted to heel plates at ends, and some with no provision against slipping. Seven tests were made with flat bars set on edge, and strung on ¼-in. rods, the plates being 2, 3, 4, 5 and 6 ins. deep, in beams 8 ins deep. Twelve tests were also made with flat bars laid flat, near the bottom of beam, with bolts ¼-in. diameter passing through bars, and terminating with nuts and washers near top of beam. The bolts

Side View of Bridge.



View from the Street.

ROLLING-LIFT BRIDGE OVER CHICAGO RIVER AT STATE ST., CHICAGO, ILL.
The Scherzer Rolling-Lift Bridge Co., Designers; Lydon & Drews and American Bridge Co., Contractors.

were spaced 4, 8, 11½ and 23 ins. apart. The bars slipped in every case when no provision was made against slipping; also in one case when riveted to heel plates, and in one case when flat bar with four bolts was used. This does not sustain Captain Sewell when he says: "It is absurd to suppose that any ordinary impact or vibration could so increase the tension in the steel as to overcome the skin friction; the steel would part first." In two tests made with flat bars 6 ins. deep, set on edge, the bars buckled, and in five tests made with bars 2, 3, 4 and 5 ins. deep, set on edge, the bars broke at bolt holes, and the deeper the bars the less the strength of the beam. Bars laid flat gave much the best results, and nearly all of them broke at bolt holes. The bolts passed through the bars and prevented slipping, which is quite diffifferent from a stirrup passing around the bar, which offers no resistance to slipping. Some of the bars were bent, but Mr. Hyatt says with no advantage. In relation to the use of bolts or straps tying the tensile and compressive parts of a beam together, Mr. Hyatt (p. 23) says:

> But all these contrivances for holding a metal tie to the concrete were devised under a misapprehension of the real nature of the strains that take place in a beam under stress, no such connections being required. A mere row of pegs or pins in a flat tie whether placed edgewise or flatwise in the concrete is all-sufficient as may be seen . . ., etc.

This quotation leads one to believe that if the "practical man," mentioned by Captain Sewell, had investigated the subject as thoroughly as Mr. Hyatt did, the world would yet have been in ignorance of his great discovery. Prof. W. K. Hatt made 17 tests on concrete-steel beams (Eng. News, July 17, 1902); none of them broke at a greater distance from the center than 6 ins., and the mean distance did not exceed 2 ins. The writer assisted in making 12 tests at Zanesville, O., 6 on concrete-steel beams, and 6 on concrete beams, and all of them broke at center or within an inch or two of it. Thirteen tests on concrete-steel beams, and one on a concrete beam, were made at the Massachusetts Institute of Technology in 1900. Twelve failed at or near the center, and two by longitudinal shear. Test No. 14, the weakest of the series, and which failed 49% below estimated strength, had stirrups connecting top and bottom of beam, spaced 9 ins. c. to c. throughout. Test pieces Nos. 12 and 13 also had stirrups. All others had no stirrups.

Four tests on concrete-steel beams, 24 ins. deep, 12 ins. wide, and 20 ft. between supports, were published in the eighth annual report of the Boston Transit Commission. The results were as follows:

	Breaking weight, lbs.
Test No. 1.—4 rods 13-16-in. square = 2.64 sq. ins., twisted steel, near bottom of beam; concrete 6 weeks old	46,000
Test No. 2.—4 rods 1-in. diameter = 3.14 sq. ins., plain steel, near bottom of beam, 2 of them horizontal for middle third of span, and bent to reach top of beam, at ends; stirrups from bottom rods to top of beam, 12 ins. apart throughout; concrete 8 weeks old	42,600
Test No. 3.—2 rods 13-16-in. square = 1.32 sq. ins., twisted steel, near bottom of beam; 2 rods 13-16-in. square = 1.32 sq. ins., twisted steel, near top of beam	34,000
Test No. 4.—2 rods 1-in. diameter = 1.57 sq. ins., plain steel, near bottom of beam; 2 rods 1-in. diameter = 1.57 sq. ins., plain steel, near top of beam; top and bottom rods connected by stirrups 12 ins. apart throughout; concrete 8 weeks old	23,000

Tests Nos. 2 and 4, with stirrups one-half depth of beam apart throughout, had the advantage of tests Nos. 1 and 3 without stirrups, both as to area of rods and age of concrete, yet gave less strength. It is evident that the stirrups were of no benefit, and may have been a positive injury.

It may be true, as Captain Sewell says, that "European practice is far ahead of American in the use of reinforced concrete," if so, American engineers and architects will undoubtedly catch up in time, as they have not been slow to adopt anything really meritorious wherever found, but if this superiority is due to the use of thin joist, T-sections, plain rods, a multitude of straps or stirrups, and slabs supported at corners, then it may be some time yet before American practice will coincide with the European. Very truly yours,

Edwin Thacher, M. Am. Soc. C.E.

Park Row Bldg., New York City, March 10, 1903.

(Proof of the above letter was submitted to Capt. Sewell and his reply is appended.—Ed.)

Sir: Mr. Thacher's letter commenting on the writer's article in Engineering News of Jan. 29 is received, and has been carefully read. The weakest point of any beam may be near the ends or at the center, depending upon design, and method of loading. It cannot be, for all possible conditions, invariably at any one point. Plate-girders have stiffeners to supply compressive strength in the web; without stiffeners, many plate girders now in service would fail by crippling the web, i. e., under shear. Great attention is paid to the ends of such girders, as well as the centers.

The writer would not neglect the center of a concrete-steel beam; on the contrary, in common with every engineer, he believes that the cross-section at the center, including the steel, should be the first point considered. All he sought to establish in his article of Jan. 29 was that after the center, the ends are also deserving of consideration, and that the highest economy and efficiency almost certainly demand it. He still thinks the data submitted justify that conclusion.

It is not supposed that the diagram of internal stresses contained in the article of Jan. 29 would be even approximately correct for a concrete-steel beam; the metal reinforcement would certainly change the distribution of internal stress very materially, but it is doubtful whether any one has been able to determine just what the result would be. The diagram answers its purpose, however, of showing that, near the ends, there probably are serious stresses with equally serious vertical components. The internal stresses as such may not start cracks at the bottom of the beam; but they may increase the cracks once they are started by deflection or otherwise. There was no intention to make this diagram mean more than it does. Current theories have thoroughly provided for the internal stresses where they become horizontal and are a maximum, so that it was thought unnecessary to dwell upon that point.

In the matter of the photographs submitted with the article of Jan. 29, one of the tests was not of a slab, as inferred by Mr. Thacher, but of four beams, supporting a slab along its four edges. This is the one that appears to have failed in the middle; but, as a matter of fact, the cracks near the reactions appeared first. The photographs represent some tests that were made with a view to the use of reinforced concrete for a storage warehouse. They were designed in this country; this much should be said in justice to European practice. They did not fully represent conditions as they would have been in the warehouse, and certainly the writer has never seen illustrations from European practice that were just like them.

Reinforced concrete was not used in the warehouse. The photographs were not submitted as models of design and construction, but merely to illustrate a mode of failure which is not uncommon. The writer has seen a good many similar failures in actual work, designed and erected by experienced men, but he had no photographs of them, and might not have cared to publish them if he had.

In the case of the T-beam—the illustration copied from a catalogue—the writer understands the diagram to have been merely illustrative of a mode of failure and its correction by stirrups; not an actual drawing of the beams that were tested.

It will be observed that all the failures illustrated or described by the writer were under loads more or less uniformly distributed. Many of those cited by Mr. Thacher were tests to destruction under concentrated center loads, and probably all of them were made in that way. This may explain the difference in results, and possibly may vindicate the writer's "practical man" as compared with Mr. Hyatt, without detraction from the great credit due to Mr. Hyatt.

Let 2 l be the span of a beam; let w be the load per unit of length, which, uniformly distributed, will produce a given maximum bending moment, M, at the center. Then, $M = \frac{w l^2}{2}$. The total load is 2 w l. The maximum moment M occurs at the center. The maximum total shear is w l, and it occurs at the ends. The shear at the center is zero. It is not impossible to conceive that the shear, w l, may be a more severe test than the moment, M. A concentrated load, w l, applied at the center, will produce the same maximum moment, $M = \frac{w l^2}{2}$, which will again occur at the center. The maximum shear will be $\frac{w l}{2}$, only half as much as before; but it will be as great at the center as at the ends. Thus, in the case of the concentrated center load, the maximum moment and maximum shear occur simultaneously, at the same point. Under these circumstances, it would be a little difficult to design a beam that would fail anywhere else than near the middle.

The value of stirrups, in such a case, might not be very apparent. But beams, in practice, must carry loads that are more or less distributed; and the writer still thinks there is evidence to justify the belief that stirrups or other vertical reinforcement is necessary near the ends, if the weakest point of the beam is to be surely confined to the center section.

The beams with stirrups, tested by the Boston Transit Commission, failed under smaller loads than other beams without stirrups. But European engineers claim to have made tests which gave exactly opposite results. In any event, there is room for more tests, before a perfectly definite result can be reached. It is quite certain that a good many beams, designed according to accepted rules, have failed at the ends, under shear. The fact that many others have not so failed does not prove that conditions at the ends should not be investigated.

The writer would like to explain that while he is not convinced of the necessity of rivet heads, short transverse bars or pins, or corrugations, to prevent slipping of the main tension rods, he thinks they are desirable as additions to the factor of safety, especially where the work of execution cannot be closely watched. He would like further to say that while supporting a floor slab at its four corners may seem a severe test, just such conditions must be met in practice, if reinforced concrete is to drive out steel frame construction, except, of course, that no bay of the slab construction would ever be isolated, and deprived of the continuous girder effects due to its neighbors. In any case, he believes that the saving due to the elimination of the steel frame will yet be a sufficient incentive for the production of successful structures involving continuous slabs supporting by isolated columns, as well as systems of reinforced concrete girders and beams supported by columns and carrying slabs, which would form, in effect, the T-sections that Mr. Thacher seems to condemn. Very truly yours,

John Stephen Sewell,
Captain, Corps of Engineers.

735 No. Capitol St., Washington, D.C., March 16, 1903.

Notes and Queries.

A. J. C., Schenectady, N. Y., writes:

What book or books treat of the theory of the fourth dimension? How far advanced in mathematics must the student be to understand the principles of the theory?

W. H. L., Boston, Mass., writes:

Can any of the readers of your paper give me information in regard to recent undertakings in concrete where chemicals have been added to the concrete on the work to secure greater hardness and wearing resistance of the finished concrete?

S. Y., Scranton, Miss., asks how sharp curves are permissible on an electric street railway line over which freight cars are to be hauled. If our correspondent will refer to our issue of March 25, 1897, he will find a detailed description of tests made at Mason City, Ia., to determine this very point. In general we may say that curves of 90-ft. radius are in use on several street railways over which freight cars are run and 50-ft. radius curves can be used, although some trouble will frequently be experienced with brake rods and couplers binding.

H. H. E., Golden, Colo., asks:

Will a stick of giant dynamite (say 45%) exert a greater force on a rock if placed in direct contact on top or if placed underneath? Does the explosion of a powder exert an equal force in all directions if free, and will a blast of dynamite exert the same effect on a rock if the hole has no tamping in it as it does if the hole is tamped?

Replying to the first question, it is certain that if the rock were resting upon the ground and sufficient dynamite were placed beneath it the rock would be shattered, where if the dynamite were placed on top of the rock it might not break it—the rock on top acts like a tamping. In answering this question we have virtually answered the latter part of the second question. Tamping of dynamite is essential to secure even fair results; for while the force of the expanding gases during explosion acts equally in all directions, and while the expansion of these gases is almost instantaneous, it is really not instantaneous. Therefore, if the explosive gases are resisted by the tamping, the force of the accumulating gases is greatly intensified by that very accumulation. Even a water tamping will serve the purpose by confining the gases momentarily.

SOME EXCELLENT WORKS IN SHAFT SINKING BY HAND DRILLING.

We are indebted to Mr. Edward H. Benjamin, M. Am. Inst. M. E., for data supplementing that recently given by him in an article in The Pacific Coast Miner, an abstract of which follows:

Work was commenced at a point 7 ft. below the 400 level and the shaft was sunk 150 ft. below that point. The work was done by hand drilling, working three eight-hour shifts, with three men on a shift. The ground was

Detailed Record of Sinking 150 ft. of Shaft at the Golden Eagle Mine, Lassen Co., Cal.

	Shifts.	Wages or price.	Totals.	Cost per ft.
Miners (9)	423	$3.00 per shift	$1269.00	$8.460
Topmen (2)	94	2.50 " "	235.00	1.566
Engineers (2)	94	3.00 " "	282.00	1.880
Blacksmith (1)	47	3.50 " "	164.50	1.096
Foreman (1)	47	$100 per mo.	172.30	1.149
Total labor	705		$2122.80	$14.151
	Quantity			
Timber	10,976 ft.	$13.00 per M.	$142.69	$ .951
Lagging	2,520 "	$.035 a piece	88.20	.588
Lining boards	2,270 "	$14.00 per M.	31.78	.212
Cordwood (blocking)	5 cords	$3.00 per cord	15.00	.100
Wedges	3000	$.01 a piece	30.00	.200
Total timber			$307.67	$2.051
Wood (fuel)	25 cords	$3.00 per cord	$75.00	$ .500
Oil and incidentals			15.00	.100
T'l power cost			$90.00	$ .600
Coal oil	6 cases	$4.15 case	$44.90	$ .166
Candles	6 "	$6.40 "	38.40	.256
Total illumination			$63.30	$ .422
Powder	600 lbs.	$.14 per lb.	$84.00	$ .560
Fuse	2,500 ft.	$3.70 per M.	9.25	.061
Caps	550	$6.25 per M.	3.44	.023
Total explosives			$96.69	$ .644
Total cost of 150 feet of shaft			$2080.46	$17.868

taken out 7 × 12 ft. in the clear—for a double compartment shaft. Hoisting was done with a bucket. The country rock hard andesite. No water was encountered. The shaft was timbered with 10 × 10-in. sawed timbers, end plates and center braces dovetailed in, and center and corner posts gained in. The sets were placed 5 ft. between centers, filled and lagged solid with 12 × 12-in. lining boards set 3 ft. apart. The work was completed in 47 shifts, making an average of 3.2 ft. per shift, hoisting 20 tons of material per shift, besides putting in timbers. The timbers were framed by hand by the foreman, who directed the work. Eighteen holes were drilled for each round, each hole 3½ to 4 ft. deep, using ¾-in. steel mostly for the drills. No. 2 Giant powder was used. The ground drilled hard, but broke well. The outside holes were kept high and the center broke first. I do not know of any work done by hand where a better record has been made.

ANOTHER WATER POLLUTION SUIT against the Muncie Pulp Co. has been decided in favor of Samuel I. Martin, of Muncie, Ind. This time the jury returned a verdict of $800 damages to Martin's farm by the pollution of Buck Creek from pulp refuse. Two years ago, it is stated, Martin recovered $2,000 damages from the same company.

A NEW METHOD OF MAKING HYDROGRAPHIC SURVEYS.*

By James H. Bacon, M. Am. Soc. C. E.†

The method used for plotting the hydrographic surveys (of Cumberland Sound) is, so far as is known to the writer, original, and seems to him worthy of description. When the work began it was evident that numerous surveys would be necessary in order to make a proper record of the rapid changes in hydrography that were to be expected, and it was also evident that the ordinary method of locating with two transits would be too cumbersome for the rapid work that would be necessary. The only other method available was that of locating with one or two sextant observers in the sounding boat. The objection to this was that the ordinary methods of plotting such locations are very slow and cumbersome. To overcome this objection protracting scales for sextant angles were drawn on skeleton maps to the scale of 1-4,800. It was found that even the best mounted drawing paper was liable to great change in contraction and expansion due to extreme changes in humidity. To obviate this the drawing paper was pasted on the drawing board, which had previously been thoroughly coated on all sides with shellac. The paper thus treated has not shown any appreciable contraction or expansion during 18 months.

The protracting scales were plotted on the principle that the angles inscribed in the same segment of a circle are equal. Thus, if A and B, Fig. 1, are the two stations observed by the sextant observer stationed at C, and a circle is drawn through the three points, A, B and C, any point on the arc A, B, C, subtends an angle equal to the angle A, C, B. Conversely, if a series of such arcs are drawn through the two points so that the successive inscribed angles differ by a constant interval, it follows that any given angle subscribed by the two points must line on some one of these ares or at a distance from it readily determined.

Such a series of arcs is readily drawn, as their centers all lie on a line perpendicular to the middle point of the line joining the two points and at a distance from it easily determined. Fig. 2 shows such a series.

By drawing a second series of arcs through two other points suitably located it is evident that the intersections of the two series furnish a reliable means of plotting the position of any point within the area covered by the two series.

In Fig. 3 the point determined by two sextant angles whose values are 77° 45" for the points A, B, and 58° 14" for the points C, D, must lie at the point marked X. The plotting of points located by two sextant angles is, however, somewhat slow by this method, although it is more rapid than by any other known to the writer. The plotting of located soundings is made much more rapid if the sounding boat is kept on a given range which can be used as one of the factors of location.

This method is shown by Fig. 4, where the straight line represent sounding ranges and pass through the same back range. Soundings located in this way can be plotted as fast as the angles can be called off from the note book.

All the surveys made here since June, 1900, have been plotted in this way by laying tracing cloth over skeleton maps drawn to the scale of 1-4,800. Range lines and arcs at intervals of 15 minutes have been drawn on these maps through all such pairs of triangulation points as were necessary for covering the ground properly.

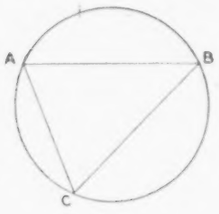


Fig. 1.

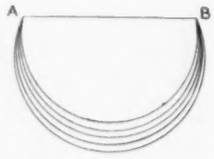


Fig. 2.

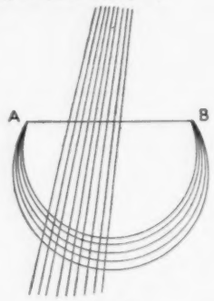


Fig. 4.

The field work and subsequent plotting of an ordinary hydrographic survey can be finished in about one-half the time that would be required by any other method. In addition to this greater rapidity this method has the advantage that an expert sextant observer can observe and read a maximum of ten angles per minute against about four angles in the case of the transit. During a day's work a sextant observer can observe and read three angles per minute comfortably, while one per minute would be the limit if he was using a transit. Other advantages are that a location can be made at any desired instant and there are no "lost" angles and no excuse for any doubtful angles; no time is lost in waiting for transitmen to go to and from station, or to change their stations in the midst of a day's work; fewer men are required, the work can be approximately plotted in the sounding boat, and the boat can be placed approximately in any desired position. Moreover, the saving of a few hours in a day's work frequently results in a total saving of many days, as bad weather often succeeds fair weather without warning and necessitates a total suspension of field work.

The plan of using range lines in lieu of an instrument for locating soundings should not be used except under the following conditions: The back range should be always clearly defined and its distance from any front range should not be less than the distance from the front range to the most distant point to be located on that line. To insure good intersection the back range should always appear between the two stations selected by the sextant observer. All ranges, both front and back, must be accurately located.

All of these conditions were easily fulfilled in this vicinity. The position of each front range is known accurately by calculating its distance angular and linear from an established triangulation point. Each front range stake was placed by means of a transit and steel tape. These sounding lines radiate from the water tower at a regular interval of 15 minutes. This affords a means for the man

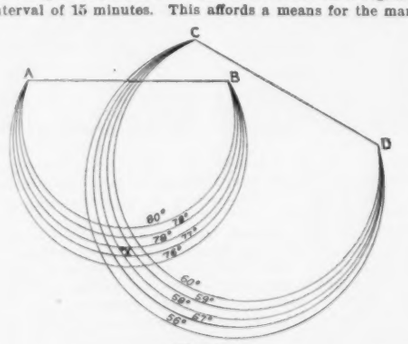


Fig. 3.

in charge of the sounding boat of knowing when the men in charge of the range flags have made an error. Not less than two flags are used so that when a shift is made any change in the angular distance is readily detected.

The preliminary field work, calculations and preparation of skeleton maps, however, consumed a period of more than three months. Hence, while the method is admirably adapted to the case in which many surveys are to be necessary over the same area, it is not so well adapted to a single survey.

*Reprinted from the Report of the Chief of Engineers U. S. A. for 1902.

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ABSTRACTS OF REPORTS PRESENTED AT THE ANNUAL MEETING OF THE AMERICAN RAILWAY ENGINEERING AND MAINTENANCE-OF-WAY ASSOCIATION.

Track.

(Note.—This report is very similar to that which was presented last year, and which was then referred back to the committee after unfavorable comment. The first section, "Maintenance of Line," is identical with the same section in the report of 1902 (Eng. News, March 27, 1902), with the exception of the addition of a few lines on the history of easement curves. The next part, "Maintenance of Surface," is also the same as before, with the following changes: 1, an additional formula for superelevation, giving a slightly different table of elevations, in which ⅛-in. is the lowest fraction used instead of 1-16-in., as in the former report; 2, the maximum superelevation for ordinary practice is 8 ins. instead of 7 ins. (the original report and the abstract in our columns gave 7 ins., but this was changed to 8 ins. in the report as published in the Proceedings). The same is true of the section on "Vertical Curves," a brief statement of modern practice being added, and the second method given in the report as abstracted last year being omitted from that report is finally printed and forms the present report. In "Maintenance of Gage," there is a brief and unsatisfactory historical statement, but in other respects the report varies but slightly from that of 1902. With the above explanation we give below the principal new matter of the report.—Ed.)

ELEVATION OF CURVES.—Your Committee advises that the approximate formula

$$E = \frac{G\ V^2}{32.16\ R}$$

will give essentially correct theoretical elevation for the outer rail of curves, and is recommended for ordinary practice, but must be modified as noted below to suit special conditions. In this formula E = elevation, in feet; G = gage of track; V = velocity, in feet per second; R = radius of curve, in feet. For greater convenience the formula above may be further reduced by substituting

$$v = V\frac{5{,}280}{3{,}600};$$

$$G = 4{,}708;$$

$$R = \frac{5{,}730}{D}\ \text{(approx.)};$$

$$e = 1\text{-}12\ E;$$

in which

V = Velocity in miles per hour;
D = Degree of curve;

and

E = Elevation of outer rail in inches;

whence

$$E = .00066\ D\ V^2.$$

This formula will give results which are expressed in the accompanying table:

Table Showing Elevation of Outer Rail in Inches.

Degree of Curve	Velocity in Miles per Hour.													Degree of Curve
	10	15	20	25	30	35	40	45	50	55	60	65	70	
1	0	⅛	⅛	⅛	⅛	⅛	1⅛	1⅜	1⅝	2	2⅜	2⅝	3⅛	1
2	⅛	⅛	⅛	1⅛	1⅜	1⅝	2⅛	2⅝	3⅛	4	4⅝	5⅜	6⅛	2
3	⅛	⅛	1⅛	1⅜	1⅝	2⅛	2⅝	3⅛	4	4⅞	5⅝	6⅝	7⅝	3
4	⅛	⅛	1⅛	1⅝	2⅛	2⅝	3⅜	4⅛	5⅛	6	7⅛	8⅜	9⅝	4
5	⅛	⅛	1⅜	1⅝	2⅜	3⅛	4⅛	5⅛	6⅜	7⅜	8⅝	9⅞	.....	5
6	⅛	⅛	1⅜	2⅛	2⅝	3⅜	4⅜	5⅝	6⅞	8	9⅜	.....	.....	6
7	⅛	⅛	1⅜	2⅛	2⅝	3⅝	4⅝	5⅞	7⅜	.....	.....	.....	.....	7
8	⅛	⅛	1⅝	2⅜	2⅞	3⅝	4⅝	6⅛	7⅝	.....	.....	.....	.....	8
9	⅛	⅛	1⅝	2⅜	3⅛	3⅞	4⅞	6⅜	7⅞	.....	.....	.....	.....	9
10	⅛	⅛	1⅝	2⅜	3⅛	4⅛	5⅛	6⅝	8⅛	.....	.....	.....	.....	10
11	⅛	⅛	1⅝	2⅝	3⅜	4⅛	5⅜	6⅞	8⅜	.....	.....	.....	.....	11
12	⅛	⅛	1⅝	2⅝	3⅜	4⅜	5⅝	7⅛	.....	.....	.....	.....	.....	12
13	⅛	⅛	1⅝	2⅝	3⅜	4⅜	5⅝	7⅜	.....	.....	.....	.....	.....	13
14	⅛	⅛	1⅝	2⅝	3⅜	4⅜	5⅝	7⅜	.....	.....	.....	.....	.....	14
15	⅛	⅛	1⅝	2⅝	3⅜	4⅜	5⅝	7⅜	.....	.....	.....	.....	.....	15
16	⅛	⅛	1⅝	2⅝	3⅜	4⅜	5⅝	.....	.....	.....	.....	.....	.....	16
17	⅛	⅛	1⅝	2⅝	3⅜	4⅜	5⅝	.....	.....	.....	.....	.....	.....	17
18	⅛	⅛	1⅝	2⅝	3⅜	4⅜	5⅝	.....	.....	.....	.....	.....	.....	18
19	⅛	⅛	1⅝	2⅝	3⅜	4⅜	5⅝	.....	.....	.....	.....	.....	.....	19
20	⅛	⅛	1⅝	2⅝	3⅜	4⅜	5⅝	.....	.....	.....	.....	.....	.....	20

VERTICAL CURVES.—The use of vertical curves wherever changes occur in the rate of grade is so universal that it does not seem necessary to enter into a discussion of the reasons requiring it. The practice, however, in regard to the length of vertical curves, the rate of change in grade per station and the method of determining the vertical curve varies greatly on different roads. Some use a parabola, others use a graphical method, and others use Wellington's, Searles' or Henck's formulas. The length of curve is arbitrarily fixed at 300 ft. to 4,000 ft. on different roads, while on other roads it is determined by the rate of change of grade per station, this rate varying from 0.3 to 0.05 on summits, and from 0.3 to 0.025 on sags.

The practice, even on the best roads, is very irregular, but the balance of opinion is also in favor of a rate in change of grade varying between 0.1 on summits and 0.05 on sags, and the parabola, or some modified form of the parabola, is used in the majority of cases.

There is no satisfactory theoretical basis on which this

question can be discussed. The flatness of the curve required must be determined by practical experience, depending upon the length and speed of trains and the character of the equipment. The object should be to make the change from one grade to another in sags so gradual that trains wil not bunch badly as the head end starts up the opposing grade. Since the introduction of automatic couplers this action is much less to be feared than formerly. But little trouble can be caused at summits from short vertical curves, unless they are carried to a point where the middle ordinate of the vertical curves would bring the truss rods dangerously close to the ground, or unless a sag is so close to the summit that the slack would not have time to straighten out.

The length of the vertical curves used in new construction will, of course, depend largely on the character of the road to be built. On high-grade passenger lines we would recommend a rate of change of 0.1 on summits and 0.05 on sags, where same can be obtained without great cost. If, however, the resulting curves will be of excessive length, or, by reason of increasing the summit cuts or causing heavy fills, would add materially to the cost, there would be no serious objection to increasing the rate of change to 0.2 on summits and 0.1 on sags. These latter rates are recommended on all roads except high-grade passenger lines and roads carrying heavy traffic or running long freight trains.

W. B. Poland, Supt., B. & O. S. W. R. R.; F. R. Coates, Ch. Engr., C. G. W. Ry.; John Doyle, Supt. of T., P. M. Ry.; Garrett Davis, Prin. Asst., C. R. & P.; C. B. Hoyt, Ch. Supt. Tr., N. Y., C. & St. L. R. R.; H. C. Landon, E. M. W., Buff. & Sus. R. R.; G. A. Mountain, Ch. Engr., Can. Atl. Ry.; D. MacPherson, Div. Engr., Can. Pac. Ry.; J. C. Sesser.

Records, Reports and Accounts.

BRIDGE REPORTS.—The work of the Committee during the past year has been limited exclusively to bridge department blanks. It is necessary, in order that there may be no misunderstanding as to the interpretation of the report, to outline some definite organization to serve as guidance for describing the course of the various reports in passing from the foreman of bridges (the lowest person making a report) through the various channels to the record office. It is not the function nor the intention of this committee to recommend any ideal organization, but rather to call attention to what seem to be the usual organizations, namely, the department system and the division system, and to call attention to the fact that the blanks recommended can by slight change of heading be adapted to either system. In general the relations existing between the several sub-departments of the general bridge department are as contained in the outline organization herewith:

ORGANIZATION OF A WORKING BRIDGE DEPARTMENT.

Foreman of Bridges or Foreman of Carpenters	In charge of a working gang.
Master Carpenter or General Foreman of Bridges and Buildings or Supervisor of Bridges and Buildings or Superintendent of Bridges and Buildings	In charge of the several working gangs and supplies of material connected with one division or district.
Division Engineer or Assistant Engineer or Engineer Maintenance-of-Way.	In general charge of engineering and maintenance-of-way work on one division or district.

DEPARTMENT SYSTEM.	DIVISION SYSTEM.
Engineer Maintenance-of-Way or Chief Engineer	Division Superintendent. General Superintendent. Engineer Maintenance-of-Way or Chief Engineer.

NOTE.—In some cases the different reports before reaching the Chief Engineer pass through the hands of the Bridge Engineer, Principal Assistant Engineer, or General Superintendent.

The committee recommends that the number of forms should be as few as possible, including only such as are absolutely necessary to convey to the higher officers such information as is necessary for the proper and economical management of the railway. As a general proposition it may be stated that too many blank forms are in use, and much information is required from time to time that leads to no adequate result. Useless reports not only worry the foreman of bridges and other officers, but involve the expenditure of funds without accomplishing any result.

The question when and how often reports should be required will have to be decided by each individual railway. The committee recommends that the general principle to be followed is to require reports so often and at such a time as will bring before the general officers such data as are necessary to guide them in making decisions as to whether the road is being operated in a safe and economical manner, and to determine what improvements are necessary and desirable. The committee also recommends that the amount of clerical work be reduced as far as possible by passing original reports up to the office in which the general records are compiled.

Certain blanks used in the bridge department, such as those for reporting the time of carpenters and other employees, are also used in the track department, and the committee recommends that the bridge department forms for reporting material and tools conform in their general arrangement as to size to the similar blanks used in the track department.

In designing forms the general principle should be followed to make a blank as universally applicable as possible, limiting as few blanks as possible to the particular requirements of a single sub-department.

BRIDGE ACCOUNTS.—The views of different railways are at variance on the general subject of ledger accounts kept in the office of the division engineer, and the committee, without making a recommendation, is of the opinion that such accounts, when consistently and carefully carried on for a long period of years, become valuable for reference and use in many ways; but such accounts are not absolutely necessary. The value of a ledger account with each bridge or structure is fully appreciated, because it is practically the only account which gives the division engineer the detail cost of important bridge work, and it is considered very important for the division engineer to make himself thoroughly familiar with the detail cost of his various pieces of bridge work so that he will be able to make careful estimates for new work.

What may be the comparative value of ledger accounts with individual bridges is not known by the committee, but there is a class of engineers which takes the position that such accounts are not worth what they cost unless in connection with some structure whose maintenance is a joint affair. The same class of engineers believes that too much distribution of accounts is needless and causes a serious addition to the clerical expense.

The radical defect in all such accounts seems to be the general lack of accuracy, this weakness in the accounts being due to the failure of railway companies to expend enough money for clerical assistance to produce an accurate system of accounts. Where ledger accounts are kept they should show the various items of labor expended and material used in connection with the maintenance of a particular bridge, and such a ledger would be kept in the office of the division engineer. There being no agreement among maintenance engineers regarding the value of ledger accounts, the committee feels justified in taking the position that the cost of annual maintenance for each individual structure is desirable and will prove valuable information if accurately and continuously kept for a long term of years, but does not think such information is absolutely essential, and, therefore, no special blank or form for the purpose is recommended for adoption.

The general subject of unit costs of construction and maintenance work is worthy of very careful study, because any deduction drawn, if accurate, will prove very valuable to the engineer. Unit costs of work are essential in any estimate according to which statements and appropriations must be made before work can be undertaken as the unit cost of executed work under conditions known to the general officers is practically the one basis on which a corrected estimate can be made.

BRIDGE INSPECTION REPORTS.—A great many roads have very elaborate and detail inspection reports, some in sheets as large as 4 sq. ft. in size, others in sheets of usual legal cap size, others in small or large book form, others in large books or sheets, one-half of each sheet being virtually a copy of the "Bridge Record Book," and finally the method of using individual blank books for field memoranda (using the "Bridge Record Book" or blue prints of the "Office Bridge Records" for reference as to information about the bridge) and subsequently in the office compiling the information on large inspection reports.

Most of the forms specify in great detail, by vertical column or side headings, the various items to be investigated at each bridge, in some cases as high as fifty items. While on particular roads and under certain organization systems this method of minute detail in the inspection reports may be working successfully, the committee does not believe that, in selecting a blank as adapted for general use, it should lose sight of the fact that there are many railroads that would not countenance this great detail, nor would they have the organization which would enable it to be carried through. To fill out these blanks conscientiously while on the ground would make the inspection cover too much time, and some roads which report such blanks as nominally standard do not rigidly carry out the system from year to year.

It is impossible to prescribe in a form headings and items to be examined which are all adapted to all classes of bridges, trestles, waterways, track openings, highway bridges, etc., and hence, in practice only part of the items can be filled in for any particular structure, and frequently special items have to be added for which usually too little space is allowed. It would seem preferable to issue instructions and rules for inspecting the various classes of structures, and leave it to the inspector to apply these rules in each particular case, mentioning in the report the general conditions and noting specially where defects are found.

BRIDGE OFFICE RECORDS.—The office of final record, whether that be Engineer Maintenance of Way or Chief Engineer, should contain such records as will enable the nature, extent, condition, strength and cost of all bridges to be ascertained at all times. Original plans of bridges showing exactly how the structure was built should be constantly on file. The information should be complete in every respect, and should show depth of foundation, character of material in the foundations, design of the superstructure, topography of the country adjacent to the bridge, and all other information necessary to the complete exhibit of the nature and character of the structure.

When it becomes necessary, by reason of the introduction of heavier motive power, to make alterations in bridges, the work should be carried out in accordance with complete plans produced by the bridge department. These drawings should be filed with the original plans, the filing clerk making such necessary cross-references in his card index system as will enable one to locate the desired drawing at once. The office of final record should also keep such records, or statements, as will show the cost of original structures, but the committee believes that no special blank is necessary for this purpose, and, therefore, none is recommended.

Edwin F. Wendt, Asst. Engr., P. & L. E. R. R.; George Houliston, Asst. Engr., Penn. R. R.; Walter G. Berg, Ch. Engr., L. V. R. R.; J. E. Turk, Supt., P. & R. Ry.; F. L. Nicholson, M. of W., N. & S. Ry.; M. L. Byers, Asst. of G. M., B. & O. R. R.; H. A. Woods, Engr. in Charge, G. T. W. Ry.; F. W. Scarborough, Engr. M. of W., C. & O. Ry.; L. F. Goodale, Ch. Engr., Bur. Lines; E. K. Woodward, Engr. M. of W., Wabash R. R.; G. H. Webster, Gen. Tie Agt., C. P. Ry.

Signs, Fences, Crossings and Cattle-Guards.

FENCES.

With the introduction of saw mills came the ordinary post and board and the picket fence. The necessity for a light and inexpensive, but easily constructed and effectual fence, as to large stock, with which to enclose great areas of land on the western prairies, brought out the barbed wire, an institution for some time peculiar to this country. This was rapidly adopted by both farmers and railways, but is now being superseded, in a measure, by some of the various forms of woven wire, in which the barbs are omitted.

The hedge fence is being used quite extensively for railway as well as farm fencing. The serious objection to such fences is that too frequently they are destroyed by fires on the right of way.

The stone fence is particularly suitable for railroad purposes. Where properly built they are durable, effective as to all kinds of live stock, and present an absolute barrier to the passage of fire from the right of way to adjoining fields. This method of construction is limited, of course, to the somparatively small area of the country in which suitable stone can be found. An excellent combination of stone and wire can be made in many places by the use of common field stones, built in a low wall of broad base, surrounding the fence posts and surmounted by woven wire. Farmers will often join in the construction of such fences at a low price in order to clear their fields of the stones.

For enclosing station grounds some form of ornamental fence should generally be used. The committee will not make any definite recommendation on this subject, but feels that the hedge fence might in many instances be adopted to good advantage.

Almost all of the before-mentioned forms of fence have been used for the purpose of defining the right of way and keeping stock from the track, but so universal for railroad purposes has become the use of barbed or woven wire fences that this report is practically restricted to the consideration of fences of that description. Various forms of plank, rail or hedge fences are being used to protect the roadbed against drifting snow, but this report does not include the subject of snow fences.

Wire.—So diverse are the results desired and materials used that no specific recommendations are made as to number and spacing of wires and spacing of posts. The following general suggestions as to construction are made:

For a hog-proof barbed wire fence the bottom wires should be "thickset" or "four-point" barbs spaced 3 ins. apart, the spacing from the ground up not to exceed 3, 4 and 6 ins.; the next three or four wires to be "regular" or "cattle" two-point barbs, 5 ins. apart; the top wire or cable to be a No. 7 plain wire, or 2-ply twisted barbless fencing, gage No. 11, or a top plank 1 × 6 ins. The barbless wire is recommended in preference to the twisted ribbon where smooth wire is desired, as the latter form has proved to be not durable. A bottom plank is not recommended for a hog-tight fence on account of its being subject to decay and liable to be burned by fires on the right of way. If difficulty is found in maintaining a hog-tight fence with the spacing of wires recommended, the introduction of vertical stays is suggested. They can, if of wire, be clamped to the wires at any time after erection of fence, or if of wood, be attached to the wires with staples. For a cattle-proof barbed wire fence, five wires, spaced from ground to first wire about 6 ins., and remaining wires from 10 to 12 ins. apart, is recommended, the wires to be "regular" or "cattle" single barbs, 5-in. spacing.

Your committee recommends the use of woven wire in preference to barbed wire for fences, and suggests the following minimum dimensions for the wires: Top and bottom wires, No. 7; intermediate wires, No. 9; stay wires, No. 11. Heavier top and bottom wires are recommended than are generally used. The life of the fence largely depends upon these two wires, and both are subjected to greater strains than the other wires, the bottom wire in addition having corrosive influences to contend with.

The height of fence and spacing of horizontal and stay wires and posts depend on the purpose for which the fence is intended. The wires should be placed on the side of the post away from the track, except on curves, where they should be so placed that the pull of the wires is against the post.

CATTLE-GUARDS.

The first form of cattle-guard was probably an open pit spanned by stringers resting upon mud sills. This was gradually elaborated into the pit-guard with timber or masonry walls, stringers carrying the rails across the opening. The vibration caused by trains shook the rubble walls ordinarily constructed to pieces, and timbers finally came into general use. The softening of roadbed in undrained locations, and consequent heaving from frost in cold weather, was destructive to the surface of track, and required continual attention on the part of the track men. In very soft material it was sometimes necessary to make a pile foundation, but this produced too great rigidity and was likewise objectionable. In quite early practice thin longitudinal strips of timber were laid across the tops of the end pieces or sills and parallel with the stringers to afford footing for pedestrians and to prevent cattle from falling into the pits. It was from this type that the surface cattle-guard of to-day was probably developed.

The certainty of piling up cars if a wheel broke or left the rails while approaching a pit-guard necessitated the use of ties in addition to the stringers, the corners of the ties being turned up or chamfered so as to afford insecure foothold for the track-walking stock. To all forms of pit-guards there are, however, serious objections, and on account of these your committee recommends that the use of pit-guards be discontinued.

The defects in and serious objections to the pit-guard have led to its abolishment on a great number of railways, and to the substitution therefor of some form of surface guard, made of wood, of metal, of combinations of wood and metal, and of other materials. Some of them are very simple in their construction, consisting merely of triangular slats either nailed to the ties or fastened together in sections, each section being fastened to the ties; others are very formidable looking contrivances, of perforated iron with sharp triangular points, saw-tooth arrangement, etc.

Your committee recommends the use of a surface cattle-guard, and that it be designed as nearly as possible to meet the following requirements: (1) It should be so constructed as to overcome the objectionable features of the pit-guard, particularly so far as endangering trains is concerned. Projecting surfaces which would be liable to be caught by dragging brake or other rigging should be avoided. (2) It should be of such construction as not to endanger employees who are compelled to pass over it. (3) It should be effective as to all kinds of live stock, and at the same time have no parts which would catch and hold stock that might endeavor to pass. (4) It should be reasonable in first cost, durable and easily applied and removed, so as to allow repairs of track at minimum expense. (5) It should not rattle during the passage of trains.

While no guard has as yet been found that will meet all of these requirements, a great many railways are being put to serious inconvenience and great expense because of the fact that while supplying the best device in the form of a cattle-guard that can be obtained, they are unable as yet to supply a guard which is absolutely effectual in turning stock, and are continually being subjected to loss on account of suits for damages due to cattle passing over guards and getting into crops or being killed. It is the opinion of this committee that it is not equitable that companies should thus be held liable for failure to supply a perfectly efficacious guard when no such device has as yet been invented, and that their duty should be completed when they furnish and maintain in good condition some form of guard which is up to the best standard of the art.

It is suggested that in those states where the laws require the maintenance of cattle-guards at road crossings it would be desirable to have the railroad commission, or other proper authority if they have any jurisdiction over the question, pass upon the different surface guards in use and on the market, specifying which of them come within the requirements of the statutes. This has been done in Michigan. In case no authority is vested in any commission that will make its decision of value, the only recourse appears to be in an effort to obtain more favorable legislation, as no guard is likely to be invented that will invariably turn stock. Observation shows that in many cases cattle do not stop to examine a guard before essaying to cross it, but plunge in regardless of consequences. It is a fact that, in doing so with pit-guards, they do not get over so frequently as with surface guards, but, falling between the ties, are then unable to extricate themselves.

CONCLUSIONS.

(1) The use of woven wire in preference to barbed wire for railway fences.

(2) The use of a heavier pattern of woven wire than has generally been adopted.

(3) The use of a heavy smooth wire, a twisted barbless cable, or a plank at top of barbed wire fence.

(4) The use of the surface in preference to the pit cattle-guard.

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Signaling and Interlocking.

HISTORICAL.

About 1834, the Liverpool & Manchester Ry. (England) introduced one of the first systems of signaling, which consisted of an upright post having at its top a rotating disk and lamp, both of which showed red for a danger signal, and for safety the absence of an indication by day, and a white light by night. Upon the opening of the Great Western Ry. an improvement upon this was introduced, in that the signal used made a distinctive display for both danger and safety indications. About 1840 the London & Southwestern Ry. introduced a vertical revolving disk, one-half being solid and the other with open segments, but this also had the fault of indicating safety by the absence of a signal, although it had the merit of being the first signal to give the engineman an indication of the fact that either the right or left or both routes were blocked.

About 1841, Sir Charles Hutton Gregory designed and erected at New Cross station on the Croydon Ry. the first semaphore signal, an adaptation of the old form of semaphore used for telegraphing over short distances, developed by Messrs. Chappe, the inventors of optical telegraphy. This was one of the most important steps taken in the development of railway signaling, and although it was rather a crude affair, yet from it, with many improvements in the general design of its several parts, has developed the semaphore signal of to-day.

The most important facts resulting from the experiments of the Chappes were: (1) That the color of any body may disappear under certain conditions of illumination, so that only the form and not the color can serve for a reliable signal. (2) That a long and narrow surface could be seen farther than the same area in the form of a circle or square, and that in average conditions of the atmosphere and on cloudy days a body 6 ft. long and 1 ft. wide, projected against the horizon, could be seen by the naked eye at a distance of 6¼ miles. At that time, as there was no communication between signal stations, a clear or satisfactory signal could, of course, give no indication to the engineman, further than that the train preceding him had passed that particular point at least a certain number of minutes previously, a man being stationed at each signal to operate it, with instructions to return a signal from "danger ahead" to "all clear" a certain number of minutes after the departure of the train. This was the origin of the "time interval" system.

Distant signals—that is, signals placed at a distance in advance of points of danger and worked by wire, etc.—were, it is believed, first introduced on the North British Ry. (Scotland), at Meadowbank station, near Edinburgh, in 1846. In 1852 the Great Northern Ry. was completely fitted with distant signals of the semaphore type.

Sir W. F. Cooke, in his pamphlet "Telegraphic Railways," published in 1842, seems to have been the first to suggest electricity in the operation of railway signals, as in this he stated principles which are embodied in the block signaling of to-day. Its first practical application was tried on the Eastern Counties Ry. about 1844. Although successful, it was abandoned in consequence of an accident and on account of its expensiveness; yet it was soon found necessary to return to this system. No improvements were made from this time until 1851, when Mr. C. V. Walker, of the Southeastern Ry., introduced the "bell code" system, which was the first audible system used. This, even as it does to-day, gave very good satisfaction, and was supplemented by Mr. Tyer, about 1852, by electric visual signals, whose object was, in several designs, to give to the operator an indication of a signal having been received and given, and at all times to show the exact position of the signal itself. Many of these "indicators" are still in use.

The "absolute" block signal system appears to have been well established in England in 1858.

The first system of interlocking switch points and signals was devised by Mr. Saxby in 1856, in England. The utilization of the up-and-down movement of the spring latch rod for actuating interlocking mechanism was introduced by Saxby & Farmer in 1867. The detector bar lock was designed by Saxby & Farmer in 1870. The system of interlocking tappets was first introduced by Stevens, of Glasgow, about 1874.

It was shortly after 1870 that railways in this country commenced to put up fixed signals, and to arrange them in such a way that it required a number of signals to give complete information or to cover a fixed territory. Prior to that time isolated signals were used for various special points, such as grade crossings, the ends of yards, etc. The first block signals used in this country were made here, but the first interlocking machine used in this country was made in England and erected here under the supervision of English mechanics. This machine was put up at East Newark, on the New York Division of the Pennsylvania R. R., in 1874.

The first power plant built was a pneumatic machine, which was erected and put into service in 1876 at the south end of the "Y" leading into the Centennial Exhibition tracks at West Philadelphia. An hydraulic machine was put into service at Wellington, O., in 1880. An hydro-pneumatic machine was first put into service at Bound Brook, N. J., in 1884. An electric machine was first put into service at Cincinnati, O., in 1889. An electro-pneumatic machine was first applied at the Jersey City terminal of the Pennsylvania R. R. in 1891.

Dwarf indicators for use in signaling two or more diverging routes were introduced on the T. & Y. Ry. in 1882 by Henry Johnson, and were simultaneously introduced in the United States by Charles R. Johnson. In 1885 this indicator gave place in the United States to Henry Johnson's "multiplex selector."

The original Hall electro-automatic wire circuit system was introduced on the Boston & Maine R. R. in 1871; the Union Signal Co.'s track circuit system was applied in 1879 on the Fitchburg R. R. The Providence & Worcester R. R. appears to have been equipped in 1881 with the first extensive application of the Union Switch & Signal Co.'s automatic track circuit block system. Pneumatic block signals were first used on the Fitchburg R. R. and on the West Shore R. R. in 1883. The first mechanical automatic block system was introduced on the New York Elevated R. R. by Robert Black in 1887.

TRAIN-ORDER SIGNALS.

On the subject of train-order signals, there is a good deal of indefiniteness. This seems to arise in part from the use of train-order signals for other purposes, and combining the functions of two or more signals into one, and calling it a train-order signal. This combined use is perfectly legitimate in some cases, and in other cases leads to confusion, so that it becomes necessary for us to try to make clear what is meant by the term "Train-Order Signal." A train-order signal naturally merges into a block signal, and it is often difficult to define the line between them. The standard code definition for train-order signals is, "A fixed signal which shall indicate 'stop' where there is an operator on duty, except when changed to 'proceed' to allow a train to pass after getting train orders, or for which there are no orders."

It seems to your committee that this definition is inaccurate and cumbersome. It is inaccurate, because a train-order signal is not always a fixed signal under present practice, flags and hand lamps being used for that purpose by a large number of our members.

CONCLUSIONS.

The train-order signal has not heretofore been located with the same exactness as that required by interlocking signal rules, but it is now time to bring this signal into line and place it where it belongs. We feel obliged, however, to recognize two forms of train-order signal: (A) The fixed signal of the semaphore type for regular use on signal and double tracks, and (B) the flag and hand-lamp signal for occasional use in special cases. The fixed train-order signal should be of such design and so located that, when the railway becomes of enough importance for block signals, the very same signal can be used in its next stage, the telegraph block signal, without throwing it away and getting another one of different design.

The American Railway Association's third and fourth requisites of installation of interlocking plants are: (3) "Signals, if practicable (to be) either over or upon the right of and adjoining the track to which they refer." (4) "Semaphore arms that govern, to be displayed to the right of the signal mast as seen from an approaching train."

The first recommendation, therefore, of your committee is that these two requisites be adopted with reference to fixed train-order signals for all numbers of tracks. The second recommendation is, that where it may be deemed advisable, for special reasons, to use a bracket mast, no more than two uprights be placed on the bracket. One of these uprights may be a stub to indicate a track not signaled. In other words, no more than one track should intervene between a bracket signal mast and the track for which its left upright carries the signal arm. The third recommendation is the recognition of the use of flags and hand lamps. The fourth recommendation is the definition of "train-order signal" as follows: "A fixed signal, of two indications, which in the stop position informs the engineman and conductor that they are to receive orders at the telegraph office, and in the proceed position announces that there are no orders for them."

Economy in signaling is obtained by uniformity in material and appliances, because they can be purchased in the open market from any signal company, and because the fewer the designs, the smaller the quantity of material and supplies to be carried in stock. The Union Switch &

Signal Co. makes 73 patterns of home signal spectacle castings. The roadway and bridge material stock of a large railway company is enormous. It is economy to keep it as small as possible. It can be done by uniformity and interchangeability.

The fifth recommendation is that the Association recommends, as the best practice, a fixed train order signal having a sweep of arm of 90° from the horizontal to the vertical. In permissive block signaling, the next logical step in advance, this third indication is a necessity. As the ultimate destiny of the fixed train-order signal is to become a block signal, let the same casting be used in both cases; in other words, let all signal castings be three-indication or position, and blind the lens hole not needed at the time, or make it a continuous light by inserting red glass in the 45° position hole. The same casting can be used both by roads having green for caution and those having yellow for caution. For those employing combinations of colors, if they desire to continue this practice, a special casting will be necessary. The vote polled on the continuous-light principle resulted in 32 for that principle, 19 for the blind shield, and 3 for no safeguard whatever. These principles, together with the angle of arm, are illustrated in Fig. 1, and this signal is recommended for adoption as the standard of the American Railway Engineering and Maintenance-of-Way Association, being the sixth recommendation of this report.

This signal is suitable for either a train-order, or interlocking, or automatic block signal. It can be used for either two or three indications, and is suitable for those roads having red for "stop," green for "caution" and white for "proceed" or "no orders," or for those having red for "stop," yellow for "caution," and green for "proceed" or "no orders." Furthermore, it is adaptable for roads desiring to be more economical, and put two arms on one mast for both directions, because the top of the mast can then be made flat and the lamp placed thereon. The mast, as well as the signal arm and casting, is recommended for standard, but neither the color of arm nor light is under consideration in the present report.

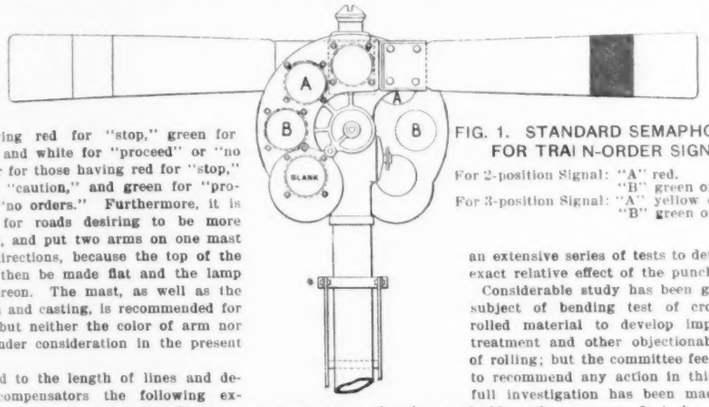

FIG. 1. STANDARD SEMAPHORE ARM FOR TRAIN-ORDER SIGNAL.

For 2-position Signal: "A" red.
"B" green or white.
For 3-position Signal: "A" yellow or green.
"B" green or white.

In regard to the length of lines and design of compensators the following expresses approximately the specification requirements of all:

(A) Each line over 50 ft. long must be compensated.

(B) One compensator is sufficient for a line 700 ft. long. But for each additional 700 ft., or fraction thereof, an additional compensator is required.

(C) The "lazy jack" pattern of compensator is required.

Compensation is effected by means of equalizing levers, rack and pinion or lazy-jack compensators and by bell cranks (where the line changes direction). Wherever the line connections to a bell crank (as frequently occurs) are such that tension on the one connection transmits compression to the other, the crank is said to be set for "reverse movement" and acts as a compensator. Their arrangement must, therefore, always be taken in consideration when locating the device designed especially for compensating. The lazy-jack compensator was patented by H. F. Cox, Sept. 6, 1901, No. 246,662.

The standard distance between centers in "pipe runs" is 2¾ ins., and as the bearing pins are frequently under the "runs," it is desirable to have them located between the lines instead of directly under a line, where they are inaccessible. A 13 or a 16-in. arm fulfills this condition.

RECOMMENDATIONS.—1. Allowance for temperature shall be made; 2, the length of compensating arms of lazy-jack compensators to be 13 to 16 ins.; 3, one compensator of the lazy-jack pattern with 13-in. arms is sufficient for a line 700 ft. long, and with 16-in. arms is sufficient for a line 1,200 ft. long.

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Iron and Steel Structures.

In continuation of its work of last year, your committee has formulated a draft of specifications for quality of material, workmanship and unit strains, and begs to submit progress reports on the subjects of live loads, impact allowance, reaming and details of design.

The question of grade of steel, which divided the committee last year, has been agreed upon this year. The subject has been pretty thoroughly discussed by the committee and among the professions at large during the year. Our agreement is upon a single grade of rolled steel for all purposes except rivets, the desired ultimate strength being 60,000 lbs. per sq. in., with an allowed range of 5,000 lbs. either above or below. In order to ascertain if the material is surely within this range, we demand two additional tests if the original test shows more than 4,000 lbs. above or below 60,000, and both of these retests must fall within the prescribed range to be acceptable.

A complete draft of the specifications is presented at the end of this report as "preliminary," with full anticipation of the probability of amendment and improvement hereafter.

On the subject of live loads we are not, as yet, ready to make any recommendations.

With respect to impact allowance the committee has made some 2,000 experiments with extensometers on various types of bridges, under train and engine loads, at various speeds, but these experiments have not been sufficiently studied to warrant us in making any deductions. It is proposed to study the results and make additional observations, if need be, with the object of finally presenting a formula for augmenting the assumed live load, so that it may be computed as static load.

On reaming, the committee has collected a large mass of information covering what has been published on the subject and also valuable experiments not heretofore in print. Comparatively few of the experiments, on which the bulk of the arguments on the subject of reaming and planing edges are based, are at all recent; and nearly all were made on steel differing widely from that considered most desirable for structural work. Arrangements are now in progress by which the committee hopes to make an extensive series of tests to determine the exact relative effect of the punch and drill.

Considerable study has been given to the subject of bending test of crop ends of rolled material to develop improper heat treatment and other objectionable features of rolling; but the committee feels reluctant to recommend any action in this line until full investigation has been made, to show what is practicable and necessary. It is hoped that experiments can be made in the future to prove the usefulness or otherwise of this method of testing.

On details of design of bridge work the committee begs to report some progress. But it has no items to offer as yet.

The following drafts of specifications for material and workmanship and a schedule of unit-strains are recommended for adoption as a basis of uniform specifications:

SPECIFICATIONS FOR MATERIAL AND WORKMANSHIP FOR STEEL STRUCTURES AND SCHEDULE OF UNIT STRAINS.

MATERIAL.

Process of Manufacture.—1. Steel shall be made by the open-hearth process.

2.—Schedule of Chemical and Physical Requirements.

	Structural steel.	Rivet steel.	Steel castings.
Max. Phos.: Basic, %.....	0.04	0.04	0.05
" " Acid, %.....	0.08	0.04	0.08
" Sulphur, %.....	0.05	0.04	0.05
Desired ult. strength, lbs. per sq. in....	60,000	50,000	Not less than 65,000
	*1,500,000	1,500,000	
Min. % elongation in 8 ins....	ult. strength	ult. strength	.....
Min. elongation in 2 ins....	22%.	.....	18%.
Features	Silky.	Silky.	Silky.§
Cold bends without fracture.	180° flat.†	180° flat.‡	90°

*See paragraph 11.
†See paragraphs 12, 13, 14.
‡See paragraph 15.
§Silky or fine granular.

The yield point, as indicated by the drop of beam, shall be recorded in the test reports.

Allowable Variations.—Tensile tests of steel showing an ultimate strength within 5,000 lbs. of that desired will be considered satisfactory, except that if the ultimate strength varies more than 4,000 lbs. from that desired, a re-test shall be made on the same gage, which, to be acceptable, shall be within 5,000 lbs. of the desired ultimate strength.

Chemical Analyses.—4. Chemical determinations of the percentages of carbon, phosphorus, sulphur and manganese shall be made by the manufacurer from a test ingot taken at the time of the pouring of each melt of steel and a correct copy of such analysis shall be furnished to the engineer or his inspector. Check analyses shall be made from finished material, if called for, in which case an excess of 25% above the required limits will be allowed.

Form of Specimens.—5. Plates, Shapes and Bars: Specimens for tensile and bending tests for plates, shapes and bars shall be made by cutting coupons from the finished product, which shall have both faces rolled and both edges milled to the form shown by Fig. 1; or with both edges parallel; or they may be turned to a diameter of ¾-in. for a length of at least 9 ins., with enlarged ends.

6. Rivets: Rivet rods shall be tested as rolled.

7. Pins and Rollers: Specimens shall be cut from the finished rolled or forged bar, in such manner, that the center of the specimen shall be 1 in. from the surface of the bar. The specimen for tensile test shall be turned

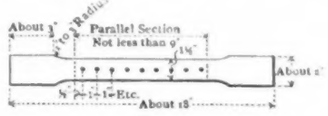

Fig.1.

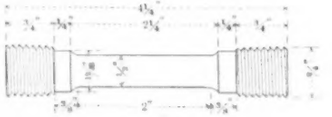

Fig.2.

to the form shown by Fig. 2. The specimen for bending test shall be 1 in. × ½-in. in section.

8. Steel Castings: The number of tests will depend on the character and importance of the castings. Specimens shall be cut cold from coupons molded and cast on some portion of one or more castings from each melt or from the sink heads, if the heads are of sufficient size. The coupon or sink head, so used, shall be annealed with the casting before it is cut off.

Annealed Specimens.—9. Material, which is to be used without annealing or further treatment, shall be tested in the condition in which it comes from the rolls. When material is to be annealed or otherwise treated before use, the specimen representing such material shall be similarly treated before testing.

Number of Tests.—10. At least one tensile and one bending test shall be made from each melt of steel as rolled. In case steel differing ⅜-in. or more in thickness is rolled from one melt, a test shall be made from the thickest and thinest metal rolled from that melt. Separate tests shall also be made for: (1) plates, (2) angles and Z-bars, (3) beams and channels, (4) bars and rods.

Modifications in Elongation.—11. For material less than 5/16-in. and more than ¾-in. in thickness the following modifications will be allowed in the requirements for elongation:

(A) For each 1/16-in. in thickness below 5/16-in., a deduction of 2½% will be allowed from the specified elongation.

(B) For each ⅛-in. in thickness above ¾-in., a deduction of 1% will be allowed from the specified elongation.

(C) For pins and rollers over 3 ins. in diameter the elongation in 8 ins. may be 5% less than that specified in paragraph 2.

Bending Tests.—12. Bending tests may be made by pressure or by blows. Plates, shapes and bars less than 1 in. thick shall bend as called for in paragraph 2.

Thick Material.—13. Full-sized material for eye-bars and other steel 1 in. thick and over shall bend cold 180° around a pin the diameter of which is equal to twice the thickness of the bar, without fracture on the outside of bend.

Bending Angles.—14. Angles ¾-in. and less in thickness shall open flat and angles ½-in. and less in thickness shall bend shut, cold, under blows of hammer, without sign of fracture. This test will be made only when required by the inspector.

Nicked Bends.—15. Rivet steel, when nicked and bent around a bar of the same diameter as the rivet rod, shall give a gradual brake and a fine silky, uniform fracture.

Finish.—16. Finished material shall be free from injurious seams, flaws, cracks or defective edges and have a workmanlike finish.

Stamping.—17. Every finished piece of steel shall have the melt number and the name of the manufacturer stamped or rolled upon it. Steel for pins and rollers shall be stamped on the end. Rivet and lattice steel and other small parts may be bundled with the above marks on an attached metal tag.

Defective Material.—18. Material which, subsequent to the above tests at the mills, and its acceptance there, develops weak spots, brittleness, cracks or other imperfections, or is found to have injurious defects, will be rejected at the shop and shall be replaced by the manufacturer at his own cost.

Allowable Variation in Weight.—19. A variation in cross-section or weight of each piece of steel of more than 2½% from that specified will be sufficient cause for rejection, except in case of sheared plates, which will be covered by the following permissible variations, which are to apply to single plates.

When Ordered to Weight.—20. Plates 12½ lbs. per square foot or heavier:

(A) Up to 100 ins. wide, 2½% above or below the prescribed weight.

(B) 100 ins. wide and over, 5% above or below.

21. Plates under 12½ lbs. per sq. ft.:

(A) Up to 75 ins. wide, 2½% above or below.

(B) 75 ins. and up to 100 ins. wide, 5% above or 3% below.

(C) 100 ins. wide and over, 10% above or 3% below.

When Ordered to Gage.—22. Plates will be accepted if they measure not more than 0.01-in. below the ordered thickness.

23. An excess over the nominal weight, corresponding to the dimensions on the order, will be allowed for each plate, if not more than that shown in the following tables, 1 cu. in. of rolled steel being assumed to weigh 0.2833 lbs.

24. Plates ¼-in. and over in thickness.

Thickness ordered.	Nominal weights.	Width of plate, in per cent. Up to 75 ins.	75 and up to 100 ins.	100 to 115 ins.
¼-in.	10.20 lbs.	10	14	18
5/16-in.	12.75 "	8	12	16
⅜-in.	15.30 "	7	10	13 to 17
7/16-in.	17.85 "	6	8	10 " 13
½-in.	20.40 "	5	7	9 " 12
9/16-in.	22.95 "	4½	6½	8½ " 11
⅝-in.	25.50 "	4	6	8 " 10
Over ⅝-in.	....	3½	5	6½ " 9

Note.—Thin plates under ⅜-in. not rolled over 115 ins. wide.

25. Plates under ¼-in. in thickness.

Thickness ordered, in.	Nominal weights, lbs. per sq. ft.	Width of plate, %. Up to 50 ins.	50 to 70 ins.	Over 70 ins.
1/8 up to 5/32	5.10 to 6.37	10	15	20
5/32 " 3/16	6.37 " 7.65	8½	12½	17
3/16 " 1/4	7.65 " 10.20	7	10	15

INSPECTION AND TESTING AT THE MILLS.

26. The purchaser shall be furnished complete copies of mill orders, and no material shall be rolled, nor work done, before the purchaser has been notified where the orders have been placed, so that he may arrange for the inspection.

27. The manufacturer shall furnish all facilities for inspecting and testing the weight and quality of all material at the mill where it is manufactured. He shall furnish a suitable testing machine for testing the specimens, as well as prepare the pieces for the machine, free of cost.

28. When an inspector is furnished by the purchaser to inspect material at the mills, he shall have full access, at all times, to all parts of mills where material to be inspected by him is being manufactured.

WORKMANSHIP.

General.—30. All parts forming a structure shall be built in accordance with approved drawings. The workmanship and finish shall be equal to the best practice in modern bridge works.

Straightening Material.—31. Material shall be thoroughly straightened in the shop, by methods that will not injure it, before being laid off or worked in any way.

Finish.—32. Shearing shall be neatly and accurately done and all portions of the work exposed to view neatly finished.

Rivets.—33. The size of rivets, called for on the plans, shall be understood to mean the actual size of the cold rivet before heating.

Rivet Holes.—34. When general reaming is not required, the diameter of the punch for material not over ⅝-in. thick shall be not more than 1/16-in., nor that of the die more than ⅛-in. larger than the diameter of the rivet. Material over ⅝-in. thick, except minor details, and all material where general reaming is required, shall be subpunched and reamed as per paragraph 62, or drilled from the solid. Rolled beams and channels used in floors of railway bridges shall be subpunched and reamed, or drilled from the solid.

Punching.—35. Punching shall be accurately done. Slight inaccuracy in the matching of holes may be corrected with reamers. Drifting to enlarge unfair holes will not be allowed. Poor matching of holes will be cause for rejection at the option of the inspector.

Assembling.—36. Riveted members shall have all parts well pinned up and firmly drawn together with bolts before riveting is commenced. Contact surfaces to be painted (see paragraph 66).

Lattice Bars.—37. Lattice bars shall have neatly rounded ends, unless otherwise called for.

Web Stiffeners.—38. Stiffeners shall fit neatly between flanges of girders. Where tight fits are called for the ends of the stiffeners shall be faced and shall be brought to a true contact bearing with the flange angles.

Splice Plates and Fillers.—39. Web splice plates and fillers under stiffeners shall be cut to fit within ⅛-in. of flange angles.

Web Plates.—40. Web plates of girders, which have no cover plates, shall be flush with the backs of angles or project above the same not more than ⅛-in., unless otherwise called for. When web plates are spliced, not more than ¼-in. clearance between ends of plates will be allowed.

Connection Angles.—41. Connection angles for floor girders shall be flush with each other and correct as to position and length of girder. In case milling is required after riveting, the removal of more than 1/16-in. from their thickness will be the cause for rejection.

Riveting.—42. Rivets shall be driven by pressure tools wherever possible. Pneumatic hammers shall be used in preference to hand driving.

43. Rivets shall look neat and finished, with heads of approved shape, full and equal size. They shall be central on shank and grip the assembled pieces firmly. Recupping and calking will not be allowed. Loose, burned or otherwise defective rivets shall be cut out and replaced. In cutting out rivets great care shall be taken not to injure the adjacent metal. If necessary they shall be drilled out.

Turned Bolts.—44. Whenever bolts are used in place of rivets which transmit shear, the holes shall be reamed parallel and the bolts turned to a driving fit. A washer not less than ¼-in. shall be used under nut.

Members to be Straight.—45. The several pieces forming one built member shall fit closely together, and finished members shall be free from twists, bends or open joints.

Finish of Joints.—46. Abutting joints shall be cut or dressed true and straight and fitted close together, especially where open to view. In compression joints depending on contact bearing the surfaces shall be truly faced, so as to have even bearings after they are riveted up complete and when perfectly alined.

Field Connections.—47. Holes for floor girder connections shall be subpunched and reamed with twist drills to a steel template 1 in. thick. Unless otherwise allowed, all other field connections shal be assembled in the shop and the unfair holes reamed; and when so reamed the pieces shall be match-marked before being taken apart.

Eye-Bars.—48. Eye-bars shall be straight and true to size, and shall be free from twists, folds in the neck or head, or any other defect. Heads shall be made by upsetting, rolling or forging. Welding will not be allowed. The forms of heads will be determined by the dies in use at the works, where the eye-bars are made, if satisfactory to the engineer, but the manufacturer shall guarantee the bars to break in the body with a silky fracture, when tested to rupture. The thickness of head and neck shall not vary more than 1/16-in. from the thickness of the bar.

Boring Eye-Bars.—49. Before boring, each eye-bar shall be properly annealed and carefully straightened. Pin holes shall be in the center line of bars, and in the center of heads. Bars of the same length shall be bored so accurately that, when placed together, pins 1/32-in. smaller in diameter than the pin holes can be passed through the holes at both ends of the bars at the same time.

Pin Holes.—50. Pin holes shall be bored true to gages, smooth and straight; at right angles to the axis of the member and parallel to each other, unless otherwise called for. Wherever possible, the boring shall be done after the member is riveted up.

51. The distance center to center of pin holes shall be correct within 1/32-in., and the diameter of the hole not more than 1/50-in. larger than that of the pin, for pins up to 5 ins. diameter, and 1/32-in. for larger pins.

Pins and Rollers.—52. Pins and rollers shall be accurately turned to gages and shall be straight and smooth and entirely free from flaws.

Pilot Nuts.—53. At least one pilot and driving nut shall be furnished for each size of pin for each structure.

Screw Threads.—54. Screw threads shall make tight fits in the nuts and shall be United States standard, except at ends of pins and for bolts over 1½ ins. in diameter, for which six threads per inch shall be used.

Annealing.—55. Steel, except in minor details, which has been partially heated shall be properly annealed.

Steel Castings.—56. All steel castings shall be annealed.

Welds.—57. Welds in steel will not be allowed.

Bed Plates.—58. Expansion bed plates shall be planed true and smooth. Cast wall plates shall be planed top and bottom. The cut of the planing tool shall correspond with the direction of expansion.

Shipping Details.—59. Pins, nuts, bolts, rivets and other small details shall be boxed or crated.

Weight.—60. The weight of every piece and box shall be marked on it in plain figures.

ADDITIONAL SPECIFICATIONS WHEN GENERAL REAMING AND PLANING ARE REQUIRED.

Planing Edges.—61. Sheared edges and ends shall be planed off ¼-in.

Reaming.—62. Punched holes shall be made with a punch 3/16-in. smaller in diameter than the nominal size of the rivets and shall be reamed to a finished diameter of not more than 1/16-in. larger than the rivet.

Reaming After Assembling.—63. Wherever practicable, reaming shall be done after the pieces forming one built member have been assembled and firmly bolted together. If necessary to take the pieces apart for shipping and handling, the respective pieces reamed together shall be so marked that they may be assembled in the same position in the final setting up. No interchange of reamed parts will be allowed.

Removing Burrs.—64. The burrs on all reamed holes shall be removed by a tool countersinking about 1/16-in.

SHOP PAINTING.

65. Steel work, before leaving the shop, shall be thoroughly cleaned and given one good coating of pure linseed oil, or such paint as may be called for, well worked into all joints and open spaces.

66. In riveted work, the surfaces coming in contact shall each be painted before being riveted together.

67. Pieces and parts which are not accessible for painting after erection, including tops of stringers, eye-bar heads, ends of posts and chords, etc., shall have a good coat of paint before leaving the shop.

68. Painting shall be done only when the surface of the metal is perfectly dry. It shall not be done in wet or freezing weather, unless protected under cover.

69. Machine finished surfaces shall be coated with white lead and tallow before shipment or before being put out into the open air.

INSPECTION AND TESTING AT THE SHOPS.

70. The manufacturer shall furnish all facilities for inspecting and testing weight, and the quality of workmanship at the shop where material is manufactured. He shall furnish a suitable testing machine for testing full-sized members if required.

71. The purchaser shall be furnished complete shop plans, and must be notified well in advance of the start of the work in the shop, in order that he may have an inspector on hand to inspect material and workmanship. Complete copies of shipping invoices shall be furnished to the purchaser with each shipment.

72. When an inspector is furnished by the purchaser, he shall have full access, at all times, to all parts of the shop where material under his inspection is being manufactured.

73. The inspector shall stamp each piece accepted with a private mark. Any piece not so marked may be rejected at any time, and at any stage of the work. If the inspector, through an oversight or otherwise, has accepted material or work which is defective or contrary to the specifications, this material, no matter in what stage of completion, may be rejected by the purchaser.

FULL-SIZED TESTS.

74. Full-sized parts of the structure may be tested at the option of the purchaser. If tested to destruction, such material shall be paid for at cost, less its scrap value, if it proves satisfactory.

75. If it does not stand the specified tests, it will be considered rejected material, and be solely at the cost of the contractor, unless he is not responsible for the design of the work.

76. In eye-bar tests the ultimate strength, true elastic limit and the elongation in 10 ft., unless a different length is called for, shall be recorded.

77. In transverse tests the lateral and vertical deflections shall be recorded.

UNIT STRAINS.

All parts of the structure shall be so proportioned that the sum of maximum strains shall not exceed the following amounts in pounds per square inch of cross-section:

Tension	16,000
Compression	$16{,}000 - 70\frac{l}{r}$

Where l is length of member in inches and r the least radius of gyration in inches.

Rivets and pins, bearing	22,000
Rivets and pins, shear	11,000
Pins, bending on extreme fibers	24,000
Plate girder webs, shearing on net section	10,000
Bearing on granite masonry	500
Bearing on sandstone, limestone and Portland cement concrete masonry	300
Expansion rollers, per lineal inch	$600 \times D$

Where D is diameter of roller.

These units to be used for all strains due to vertical and lateral loads, with the strains due to train loads reduced to equivalent static loads by a proper impact formula.

Respectfully submitted, J. P. Snow, Bridge Engr., B. & M. R. R.; B. Douglas, Bridge Engr., M. C. R. R.; John Brunner, Asst. Gen. Supt., Ill. Steel Co.; T. L. Condron, Cons. Engr.; C. L. Crandall, Prof. of R. R. Eng., Cornell University; J. E. Greiner, Engr. B. & B., B. & O. R. R.; Wm. M. Hughes, Cons. Bridge Engr.; Wm. Michel, Engr. M.-of-Way, Hocking Valley R. R.; C. C. Schneider, Vice-Prest., Am. Bridge Co.; J. R. Worcester, Cons. Engr.

MASONRY.

Your committee has taken up in this report the consideration of concrete and cement.

Concrete being a mass of broken stone or gravel cemented together by a matrix, it follows that having selected the stone or gravel, it is necessary that the proper amount of matrix be determined. There should be an excess of matrix to insure the entire surface of all the stone or gravel being covered with the cementing material. Experience shows this should be from 5% to 10% of the voids.

Various writers recording experiments with broken stone and gravel place the voids at from 41% to 50% of the mass. A number of experiments with crushed blue limestone, well shaken but not rammed, conducted under the direction of the chairman of this committee, gave the following:

Size of broken stone.	Weight of 1 cu. ft.	Per cent. of voids
Crusher run with dust screened out	89.222	45.16
Stone which passed 2-in. grating and retained in 1-in.	86.741	47.70
Stone which passed 2-in. grating and retained in ½-in.	77.701	50.66
Pea size	75.444	49.63

In all cases the necessity of thoroughly washing all dust from the stone and wetting it down cannot be too strongly impressed.

SPECIFICATIONS FOR PORTLAND CEMENT CONCRETE.

Cement shall be Portland, either American or foreign, which will meet the requirements of the standard specifications.

Sand shall be clean, sharp and coarse, but preferably of grains varying in size. It shall be free from clay, loam, sticks and other impurities.

Stone shall be sound, hard and durable, crushed to sizes not exceeding 2 ins. in any direction and free from dust by screening.

Gravel shall be composed of clean pebbles of hard and durable stone of sizes not exceeding 2 ins. diameter, free from clay and other impurities except sand. When containing sand in any considerable quantity, the amount per unit of volume of gravel shall be determined accurately to admit of the proper proportion of sand being maintained in the concrete mixture.

Water shall be clean and reasonably clear, free from sulphuric acid or strong alkalies.

Mixing by Hand.—1. Tight platforms shall be provided of sufficient size to accommodate men and materials for the progressive and rapid mixing of at least two batches of concrete at the same time. Batches shall not exceed 1 cu. yd. each, and smaller batches are preferable, based upon a multiple of the number of sacks to the barrel.

2. Spread the sand evenly upon the platform, then the cement upon the sand and mix thoroughly until of an even color. Add all the water necessary to make a thin mortar and spread again; add the gravel it used, and finally the broken stone, both of which if dry should first be thoroughly wet down. Turn down the mass with shovels or hoes until thoroughly incorporated, and all the gravel and stone is covered with mortar; this will probably require the mass to be turned four times.

3. Another approved method which may be permitted at the option of the engineer in charge is to spread the sand, then the cement, then the gravel or broken stone; add water and mix thoroughly as above.

Mixing by Machine.—A machine mixer shall be used wherever the volume of work will justify the expense of installing the plant. The necessary requirements for the machine will be that a precise and regular proportioning of materials can be controlled and the product delivered be of the required consistency and thoroughly mixed.

Consistency.—The concrete shall be of such consistency that when dumped in place it will not require tamping; it shall be spaded down and tamped sufficiently to level off and will then quake freely like jelly, and be wet enough on top to require the use of rubber boots by the workmen.

Course.—1. Each course should be left somewhat rough to insure bonding with the next course above; and if it be already set, shall be thoroughly cleaned and dampened before the next course is placed upon it. The plane of courses shall be as nearly as possible at right angles to the line of pressure.

2. An uncompleted course shall be left with a vertical joint where the work is stopped.

3. The work should be carried up in sections of convenient length and completed without intermission.

Expansion Joints.—1. In exposed work expansion joints shall be provided at intervals of 30 to 50 ft. A temporary vertical form or partition of plank shall be set up and the section behind completed as though it were the end of the structure. The partition will be removed when the next section is begun and the new concrete placed against the old without mortar flushing. Locks shall be provided if directed or called for by the plans.

2. In reinforced or steel concrete the length of these sections may be materially increased at the option of the engineer.

Time.—Concrete shall be placed immediately after mixing and any having an initial set shall be rejected.

Facing.—About 1 in. of mortar of the same proportions as used in the concrete may be placed next to the forms, immediately in advance of the concrete, or a shovel facing made, at the option of the engineer in charge.

Forms.—1. Shall be substantial and unyielding, properly braced or tied together by means of wire or rods.

2. The material used shall be of dressed lumber, secured to the studding or uprights in horizontal lines.

3. Planking once used in forms shall be cleaned before being used again.

4. The forms must not be removed within 48 hours after all the concrete in that section has been placed. In freezing weather they must remain until the concrete has had a sufficient time to become thoroughly set.

5. In dry but not freezing weather the forms shall be drenched with water before the concrete is placed against them.

6. For backings, undressed lumber may be used for forms.

Finishing.—1. After the forms are removed, any small cavities or openings in the concrete shall be neatly filled with mortar if necessary. Any ridges due to cracks or joints in the lumber shall be rubbed down; the entire face shall then be washed with a thin grout of the consistency of whitewash, mixed in the proportion of 1 part of cement to 2 parts of sand. The wash should be applied with a brush.

2. The tops of bridge seats, pedestals, copings, wing walls, etc., when not finished with natural stone coping, shall be finished with a smooth surface composed of 1 part cement to 2 parts of granite, or other suitable screenings, or sand applied in a layer 1 to 1½ ins. thick. This must be put in place with the last course of concrete.

3. In arch tops a thin coat of mortar or grout shall be applied over the top to thoroughly seal the pores.

Proportioning.—The proportion of the materials in the concrete shall be as if specifically called for by the contract, or as set forth herein, upon the lines left for that purpose; the volume of cement to be based upon the actual cubic contents of one barrel of specified weight.

SPECIFICATIONS FOR NATURAL CEMENT.

Definition.—Natural cement is a product formed of calcinated limestone containing clay and carbonate of magnesia reduced to a fine powder.

Packages.—Cement shall be packed in well made wooden barrels lined with paper, or in strong jute or paper sacks. Each package shall be plainly marked with the brand and name of the manufacturer and the net weights shall be exact and uniform.

Weight.—The average weight per barrel shall not be less than 300 lbs., except that west of the Allegheny Mountains this may be 265 lbs. Three paper sacks of cement shall be equivalent in weight to one barrel, or two jute sacks containing not less than 133 to 150 lbs., to the sack.

Condition.—All cement shall be delivered in sound packages, undamaged by moisture or other causes.

Storage.—Cement must be stored until used in a perfectly dry place in such manner as will insure it from all damage.

Rejection.—All cement failing to meet the requirements of the specifications may be rejected, and all rejected cement, whether damaged or rejected for other causes, shall be removed at once from the company's property.

Tests.—All cement shall be subject to the following tests:

Sampling.—1. The selection of the sample for testing, the number of packages sampled, and the quantity taken from each package, must be left to the discretion of the engineer, but each sample should be a fair average of the contents of the package from which it is taken. At least one barrel in every ten should be sampled.

2. Cement in barrels should be sampled through a hole made in the center of one of the staves, midway between the heads, or in the head, by means of an augur or sampling iron similar to that used by sugar inspectors. If in bags, it should be taken from surface to center.

3. All samples should be passed through a sieve having 20 meshes per linear inch in order to break up lumps and remove foreign material. For determining the characteristics of carload shipments of cement the individual samples may be mixed and the average tested; where time will permit, however, each sample shall be tested separately.

Fineness.—Not less than 80% of the cement tested shall pass through a No. 100 standard sieve. The standard sieve shall be circular about 20 cm. (7.87 ins.) in diameter, 6 cm. (2.36 ins.) high and provided with a pan 5 cm. (1.97 ins.) deep and a cover. The wire cloth in the sieve to be woven (not twilled) from brass wire, having a diameter of 0.0045-in. This cloth to be mounted in the frame without distortion; the mesh should be regular in spacing and for a No. 100 sieve shall contain not less than 96 nor more than 100 meshes per lin. in. The cement to be thus tested shall be thoroughly dried at a temperature of 100 C (212° F.) before sieving.

Set.—1. Initial set shall not occur in less than 20 minutes.

2. Final set shall not occur in less than 45 minutes nor more than four hours.

3. The time of setting shall be determined by means of the Vicat needle apparatus as recommended by the committee of the American Society of Civil Engineers upon uniform tests of cement, in conjunction with the committee of the International Association for Testing Materials.

4. Using a paste composed of neat cement and water, of normal consistency, the initial set is said to have commenced when the needle ceases to pass a point 5 mm. (0.20 ins.) above the upper surface of the glass plate in the Vicat apparatus, and is said to have terminated the moment the needle does not sink visibly into the mass.

5. The paste is of normal consistency when the cylinder of the Vicat apparatus penetrates to a point in the mass 10 mm. (0.39 ins.) below the top of the ring.

6. The amount of water required to make a paste of normal consistency varies with different cements, but will be found to be approximately 30% of the weight of the cement. It should have a temperature of 70° F.

Soundness.—1. Cold Water Test. A pat of neat cement 2½ to 3 ins. diameter, ½-in. thick at center, tapering to a thin edge, and allowed to take its final set in moist air, must withstand indefinite exposure in water or air at any ordinary temperature without checking, distortion or softening.

Tensile Strength.—1. The briquette used in testing shall be formed in molds of the size and form now in customary use and recommended by the American Society of Civil Engineers, the stress to be applied at a uniform rate of 400 lbs. per minute until fractured.

2. All briquettes of neat cement are to be made from paste of normal consistency in the following manner: The molds should be filled with the paste as soon as it is thoroughly mixed and tempered, the material pressed in firmly with the fingers and smoothed off with a trowel without ramming; the material should be heaped up on the upper surface of the mold and in smoothing off, the trowel should be drawn over the mold in such a manner as to exert a moderate pressure upon the excess material. The mold should then be turned over and the operation repeated on the other side.

3. Briquettes for 24-hour tests shall be allowed to set in moist air until finally set and be placed in water for the balance of the 24 hours.

4. Briquettes for 7 and 28-day tests shall be allowed to set one day in moist air and remainder of period in water.

5. All briquettes are to remain in the water until they are placed in the testing machine.

6. Neat 24-hour tests shall not show less than 60 lbs. per sq. in. Neat seven-day tests shall not show less than 100 lbs. per sq. in. Neat 28-day tests shall not show less than 150 lbs. per sq. in., nor less than 25% above the seven-day test.

Specific Gravity.—The specific gravity determined upon dried cement which has passed through a No. 100 sieve shall not be less than 2.50 nor more than 2.80. The specific gravity can be conveniently and accurately determined by the use of Le Chatelier's apparatus as recommended by the committee on uniform tests of cements.

Uniformity.—If in the tests of any given brand of cement, any sudden irregular or wide variation from its normal action is found, it should be withheld from use until more extended tests shall have demonstrated its reliability.

SPECIFICATIONS FOR PORTLAND CEMENT.

Definition.—Portland cement is a product of the mixture of clay and lime carbonate in definite proportions, calcinated at a high temperature and reduced to a fine powder.

Packages.—Cement shall be packed in well-made wooden barrels lined with paper, or in strong cotton or paper sacks. Each package shall be plainly marked with the brand and name of the manufacturer and the net weights shall be exact and uniform.

Weight.—One barrel shall contain not less than 375 lbs. of cement and four sacks shall be equivalent in weight to one barrel.

Condition.—All cement shall be delivered in sound packages, undamaged by moisture or other causes.

Storage.—Cement must be stored until used in a perfectly dry place in such manner as will insure it from all damage.

Rejection.—All cement failing to meet the requirements of the specifications may be rejected, and all rejected cement, whether damaged or rejected for other causes, shall be removed at once from the company's property.

Tests.—All cement shall be subject to the following tests: (Sampling to be as given above for natural cement.—Ed.)

Fineness.—Not less than 94% of the cement tested shall pass through a No. 100 standard sieve. The standard sieve shall be circular, about 20 cm. (7.87 ins.) in diameter, 6 cm. (2.36 ins.) high, and provided with a pan 5 cm. (1.97 ins.) deep, and a cover. The wire cloth in the sieve to be woven (not twilled) from brass wire, having a diameter of 0.0045 in. The cloth to be mounted in the frame without distortion; the mesh should be regular in spacing and for a No. 100 sieve shall contain not less than 96 nor more than 100 meshes per lin. in. The cement to be thus tested shall be thoroughly dried at a temperature of 100 C. (212° F.) before sieving.

Set.—1. Initial set shall not occur in less than 30 minutes.

2. Final set shall not occur in less than one hour nor more than ten hours.

3. The time of setting shall be determined by means of the Vicat needle apparatus as recommended by the committee of the American Society of Civil Engineers upon uniform tests of cement, in conjunction with the committee of the International Association for Testing Materials.

4. Using a paste composed of neat cement and water, of normal consistency, the initial set is said to have commenced when the needle ceases to pass a point 5 mm. (0.20 in.) above the upper surface of the glass plate in the Vicat apparatus, and is said to have terminated the moment the needle does not sink visibly into the mass.

5. The paste is of normal consistency when the cylinder of the Vicat apparatus penetrates to a point in the mass 10 mm. (0.39 in.) below the top of the ring.

6. The amount of water required to make a paste of normal consistency varies with different cements, but will be found to be approximately 20% of the weight of the cement. It should have a temperature of 70° F.

Soundness.—1. Cold Water Test. A pat of neat cement 2½ to 3 ins. diameter, ½-in. thick at center, tapering to a thin edge, and allowed to take its final set in moist air, must withstand indefinite exposure in water or air at any temperature without checking, distortion or softening.

2. Boiling Water Test.—A pat of neat cement as above, placed in water, which shall be slowly raised to the boiling point and then maintained in that condition for three hours and allowed to cool gradually, shall not show any signs of checking, distortion or softening. The same result should follow exposure to steam not under pressure for three hours. This test may or may not be cause for rejection at the option of the engineer in charge.

Tensile Strength.—1. The briquette used in testing shall be formed in molds of the size and form now in customary use and recommended by the American Society of Civil Engineers, the stress to be applied at a uniform rate of 600 lbs. per minute until fractured.

2. All briquettes of neat cement are to be made from paste of normal consistency in the following manner: The molds should be filled with the paste as soon as it is thoroughly mixed and tempered, the material pressed in firmly with the fingers and smoothed off with a trowel without ramming; the material should be heaped up on the upper surface of the mold and in smoothing off, the trowel should be drawn over the mold in such a manner as to exert a moderate pressure upon the excess material. The mold should then be turned over and the operation repeated upon the other side.

3. Briquettes for 24-hour tests shall be allowed to set in moist air until finally set and be placed in water for the balance of the 24 hours.

4. Briquettes for 28-day tests shall be allowed to set one day in moist air and remainder of period in water.

5. All briquettes are to remain in the water until they are placed in the testing machine.

6. Neat 24-hour tests shall not show less than 125 lbs. per sq. in. Neat seven-day tests shall not show less than 400 lbs. per sq. in. Neat 28-day tests shall not show less than 500 lbs. per sq. in., and should show 10% or more increase above the seven-day test.

Specific Gravity.—The specific gravity determined upon dried cemnt which has passed through a No. 100 sieve shall not be less than 3.10 nor more than 3.30. The specific gravity can be conveniently and accurately determined by the use of Le Chatelier's apparatus as recommended by the committee on uniform tests of cements.

Chemical.—Chemical analyses should show not more than 3.5% of magnesia, nor more than 1.75% of sulphuric anhydride.

Uniformity.—If in the tests of any given brand of cements any sudden irregular or wide variation from its normal action is found, it should be withheld from use until more extended tests shall have demonstrated its reliability. Respectfully submitted,

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Ballasting.

Of all the mileage of the country, less than half has any ballast at all, and of that ballast, more than half is gravel. Next come the various refuse products of engines, mills, furnaces, etc., namely, cinders and slag; then broken stone, then mine tailings, and finally artificial ballast in the form of burnt clay.

SPECIFICATIONS FOR BALLAST.

Engine Cinders.

Roads having a total trackage of 72,055 miles (46,894 miles of it main line), report 5,186 miles of ballast with cinders, 7,753 miles with stone, and 16,331 miles with gravel.

Engine cinders make a good ballast for sidings, yards and lines of light traffic; they make a good sub-ballast on new work where dumps are settling, etc.; they are good in wet places; they are good on temporary work; they are easily handled. Anthracite coal cinders are better than soft coal, and there is considerable difference in the quality of cinders obtained from different kinds of soft coal. The chemical action tending to destroy rails and ties probably varies greatly, but generally the effect on both ties and rails is injurious to a greater or less extent. They should not be used on main lines subject to heavy traffic.

Stone Ballast.

1. Quality.—A. Stone should be durable enough to resist the disintegrating influences of the climate where it is used. B. It should be hard enough to prevent pulverizing under the class of traffic to which it is subjected. C. It should break in angular pieces when crushed.

2. Size.—A. It is recommended that the maximum size of ballast shall not exceed pieces which will pass through a 1¾-in. ring, but a ring of 1½-in. diameter is preferred as the maximum measure of size. B. It is recommended that the minimum size will not pass through a screen with ¼-in. holes.

3. Quantity in Track.—A. It is recommended that the minimum thickness of 6 ins. under the tie be considered as ballasted track, but that a minimum thickness of 8 ins. under the tie is preferred. B. The extreme maximum thickness of 18 ins. under the tie is recommended, with an ordinary maximum of 12 ins.. C. The upper surface of the ballast should be level with the top of the ties. D. The upper surface of the ballast should extend 9 ins. beyond the ends of the ties. E. The slope should not be steeper than 1½ to 1.

Burnt Clay.

Burnt clay or gumbo ballast is of quite recent use, and nearly, if not quite, confined to the territory in the central basin of the country where sufficient quantities of good stone or gravel cannot be obtained without excessive cost. While it is hardly practicable at the present time to draw up a complete set of specifications for burnt clay ballast, we would suggest as follows:

A. It should be made from clay free from sand or soil and should be thoroughly tested in small test kilns before establishing a ballast kiln.

B. Clay must be thoroughly burnt.

C. Coal must be fresh and clean enough to burn with a clean fire.

D. Quantity of fuel and time of burning will vary with the nature of the clay and the weather conditions.

E. Burning should be done under the supervision of an experienced and competent burner.

F. Care should be taken that fuel is always on hand when required.

G. Ballast should not be loaded out of the pit hot.

H. Absorption of water should not exceed 15%.

Where fuel is cheap and suitable material can be obtained, clay ballast can be obtained f. o. b. at about the same cost as crushed rock. The cost of putting burnt clay ballast under the track is much less than for stone, and for a time much easier to maintain. The life of burnt clay ballast seems to be from four to eight years, depending on the quality of same and the amount of traffic it has to sustain.

Gravel Ballast.

Gravel to make good ballast must be composed of firm particles that will not readily decay, and in sizes running from coarse sand to 1½ ins. diameter. It must be sufficiently free from clay and soil to allow drainage. Gravel ballast of irregular boulders and containing considerable clay can be made into first-class gravel, usually by passing it through a washer and crusher, the larger boulders being crushed into small, irregular masses, giving a superior holding quality on the tie, and the washing will make the ballast drain so it will not churn in wet weather.

CONCLUSIONS.

1. Very little of the railway mileage of the country can be maintained with any degree of satisfaction with the material that forms the roadbed. Almost always selected material is demanded that must be transported and put into the track.

2. There is a great variety of natural or artificial material obtainable in various localities that meets the demands more or less perfectly, and which it is good policy to use. With the increase of speed and weight of engines and cars, the duty called for on ballast has grown more exacting, and materials that gave satisfactory results under 30,000-lb. axle loads fail in a short time under 45,000 and 50,000-lb. axle loads now coming into use.

3. Except where an exceptionally good quality of gravel is obtainable it is the opinion of the committee that only stone ballast, made from hard durable stone and broken in sizes from ¾-in. to 1½ ins., and having a depth of 12 ins. under the tie, resting on a firm, well-drained roadbed, will meet the requirements of roads with heavy traffic using maximum-sized engines and having fast service.

4. Ballast may fail from a variety of causes. It may not stand the action of the weather. This is true of most sandstones, some limestones, and most artificial ballasts. It may not have sufficient strength to resist crushing. This is true of some rocks, slags, cinders, chats and artificial ballast.

5. It may wear out and become pulverized by the grinding of the pieces against each other and from frequent tamping. This is true of all ballast more or less, but is less marked in good stone and gravel than with other varieties.

6. It may fail for want of weight or cohesion, and be blown or washed away, and fail to hold the tie in position. This is true of sandy gravel and chats.

7. It may fail on account of a large part of the pieces being of a globular shape, with smooth surfaces, which allow the pieces to move as well as the tie. This is generally true of beach or river bed gravel and some pit gravel.

8. It may fail for want of support from below, especially if the top of the roadbed becomes concave and has defective darinage. This is a failure of the roadbed rather than the ballast.

E. Holbrook, Ch. Engr., M., K. & O. Ry.; F. A. Molitor, Ch. Engr., C., O. & G. Ry.; S. B. Fisher, Ch. Engr., M., K. & T. Ry.; J. V. Hanna, Asst. Ch. Engr., St. L. & S. F. R.; C. R. Paquette, Supt., P. & E. Ry.; M. P. Paret, Ch. Engr., K. C., M. & O.; W. B. Storey, Jr., Ch. Engr., Santa Fe Ry.; G. M. Walker, Jr., Asst. Engr. and Roadmaster, Kansas City Belt Ry.; H. U. Wallace, Ch. Engr., I. C. R. R.

Ties.

PRESERVATIVE PROCESSES.

The data gathered for this year's report simply confirm the statements heretofore given as to the average life of treated ties in this country. The record of treated pine ties taken out of the tracks of the Atchison, Topeka & Santa Fe Ry. during 1901, compiled under the direction of Mr. H. U. Mudge, General Manager, show the following:

Removed in 1897 on 6 divisions, average life, 10.18 yrs.
Removed in 1898 on 7 divisions, average life, 10.56 yrs.
Removed in 1899 on 8 divisions, average life, 10.61 yrs.
Removed in 1900 on 9 divisions, average life, 10.78 yrs.
Removed in 1901 on 10 divisions, average life, 10.58 yrs.

Mr. Mudge says:

Special attention should be called to the fact that these figures represent only the average life of treated ties taken out on account of rot, and not the average life of all ties treated during each year. Also: It must not be overlooked that it is the "weak sisters" which come out first; the strong, sound ones remaining in a much longer time, under the principle of the survival of the fittest.

On the Chicago, Rock Island & Pacific Ry. the returns of treated ties renewed in 1901 show an average life on that road east of the Missouri River of 10.66 years, and it is estimated at one year more west of the Missouri River.

On the Southern Pacific Ry. the records may be summarized as follows: On the Atlantic System, total number of treated ties laid, beginning with 1887, 2,971,382. Total number removed to June 30, 1902, 641,918. All ties laid in 1887-8-9 had been removed; 17% of the 1890, 64% of the 1891, 83% of the 1892 and 90% of the 1893 ties are reported to be still in track. On the Pacific System, total number of treated ties laid, beginning with 1894, 5,491,976. Total number removed, 251,961. 85% of the ties laid in 1894, 75% of the 1895, 85% of the 1896, 94% of the 1897 and 98% of the 1898 are still in track.

LIST OF TIMBER PRESERVING PLANTS IN THE UNITED STATES.

Location.	Year built.	Owner.	Process.	Kind of wood.	No. retorts.	Est'd capacity ties per annum.
Lowell, Mass.	1848	Locks & Canal Co.	Kyanizing	Various	2	30,000
Las Vegas, N. M.	1885	A., T. & S. F. R. R.	Burnettizing	Pine	3	500,000
Bellemont, Ariz.	1898	A., T. & S. F. R. R.	Burnettizing	Pine	2	350,000
Chicago, Ill.	1886	Chi. Tie Pre. Co.	Zinc-tannin	Hemlock	4	600,000
Mt. Vernon, Ill.	1899	Chi. Tie Pre. Co.	Zinc-tannin	Black Oak	1	200,000
Somerville, Tex.	1897	Tex. Tie & L. Co.	Zinc-tannin	[illegible], etc.	6	2,000,000
Kalispell, Mont.	1901	Gt. Northern Ry.	Zinc-tannin	Pine Fir	4	1,200,000
Houston, Tex.	1891	So. Pacific Co.	Burnettizing	Pine	5	1,500,000
Oakland, Cal.	1889	So. Pacific Co.	Creosoting	Pine, etc.	2	1,000,000
Cal. & Oregon	1894	So. Pacific Co.	Burnettizing	Pine Fir	2	1,000,000
Beaumont, Tex.	1897	Int'l Creo. & Cons. Co.	Various	Pine, etc.	1	300,000
Sheridan, Wyo.	1899	C., B. & Q. Ry.	Burnettizing	Pine, etc.	2	500,000
Greenville, Tex.	1901	Mo., Kan. & Tex. Ry.	Zinc-tannin	Pine Gum	3	800,000
Alamagordo, N. M.	1902	Ala. Lumber Co.	Zinc-tannin	Pine, etc.	2	600,000
Portable Plant.	1902	Union Pac. Ry.	Zinc-tannin	Pine, etc.	2	600,000
Portable Plant.	1902	Oregon Short Line	Zinc-tannin	Pine, etc.	2	600,000
Carbondale, Ill.	1902	Ayer-Lord Tie Co.	Various	Red Oak	6	2,000,000
Grenada, Miss.	1902	Ayer-Lord Tie Co.	Various	Pine, etc.	2	800,000
Long Island City.	1878	Eppinger & Russell	Creosoting	Pine, etc.	4	800,000
Perth Amboy, N. J.	1890	U. S. Wood Pres. Co.	Creo. Resin	Pine, etc.	4	1,200,000
Norfolk, Va.	1896	Norfolk Creo. Co.	Creosoting	Pine, etc.	4	900,000
W. Pascagoula, La.	1876	L. & N. R. R.	Creosoting	Pine, etc.	2	400,000

While it is not improbable that some new methods of timber preservation may prove to have value, and while it is important that they should be tested experimentally, it is assumed that, for the present, our railroads will chiefly hold to the processes which have stood the test of time. The most successful of these are: (1) Creosoting, (2) zinc-creosote, (3) burnettizing, and (4) zinc-tannin or Wellhouse process.

It seems desirable to emphasize the necessity for careful and conscientious supervision of the operation of a timber-treating plant. The value of treated timber, when exposed to the action of the elements, as with railroad ties in contact with the ground and with moisture, depends upon a number of conditions, such as the kind of wood, its treatment and its subsequent exposure, as well as with the process which may have been adopted. Most important of all is the thoroughness with which the work is done. Although the processes are apparently simple, experience has shown that there are quite a number of precautions which must be observed in order to produce good work.

(1) SEASON TIES UNTIL FIT FOR TREATMENT.—This is universally done in Europe. In the United States there is divergence of opinion; the Southern Pacific Co. claiming that ties of Oregon fir are best impregnated fresh cut. This may be the result of resin and slimy sap in the wood, which does not resist the entrance of the chemicals when limpid, but dries in the pores and gums the outer surfaces. In Germany the difficulty is met by sawing off thin slabs from each end of telegraph poles which have been seasoned before treating them, as the impregnating fluid chiefly enters at the ends, and not from the side surfaces. The readiest way of governing the seasoning required for American woods will be to establish by experiment their weight per cubic foot when in condition to be impregnated throughout; which may be ascertained by chemical analysis of borings from the center, quarters and ends of treated ties, allowed to season for varying times before treatment. Room must be made in the wood for the solution, either by the natural seasoning or by extracting the sap. It is claimed by some authorities that more sap in actual bulk can be extracted from a half-seasoned tie than from one fresh from the saw, although the latter contains a greater quantity. On the Chicago & Eastern Illinois R. R. ties are treated in the order of their cutting, so that all shall get the same amount of seasoning.

All parties, therefore, in charge of tie-treating plants should give particular attention to the condition of the wood at the time it goes into the retort.*

*In France, beech is seasoned to weigh 45.5 to 46.7 lbs. per cu. ft., and European oak to 52 lbs. per cu. ft. In Germany, oak is seasoned to 50 lbs., beech to 45.1 and pine to 39.2 lbs. per cu. ft. before treatment.

(2) DO NOT MIX TIES OF DIFFERENT SEASONINGS.—This is obvious enough, and yet is frequently disregarded. It is clear that when ties of different degrees of seasoning are treated in one retort, some will absorb more than others, and the treatment will not be uniform.

(3) TEST THE CHEMICALS FOR PURITY, ETC.—This is much more carefully attended to in Europe than in this country. Each plant has a chemist.

(4) INJECT LIBERAL QUANTITIES OF CHEMICALS.—It is assumed that for the present the chief processes used in the United States will involve the injection of chloride of zinc. The present German practice is to inject the equivalent of ½ lb. of the dry salt of chloride of zinc per cu. ft. of wood. This was arrived at after some disappointing experiences with lesser amounts, and it seems well to follow this practice.

(5) VARY THE STRENGTH OF SOLUTION TO PRODUCE ABOVE RESULTS.—Ties being generally cut in winter become better seasoned in the late summer and autumn. The strength of the solution should then be reduced so as to inject the same equivalent of dry chloride as before. Indeed, if the amount determined on is injected, the weaker the solution, the better; for the antiseptic is more thoroughly distributed in the wood. This fact has sometimes led to the erroneous inference that weak solutions were more effective because they were feeble, whereas it was the uniform dissemination which produced the results.

(6) WEIGH THE BUGGY LOADS IN AND OUT. TREAT AGAIN IF DEFICIENT.—The universal practice in Germany is to weigh each buggy load (32 ties) before running it into the retort, and to weigh it again afterward. Thus is ascertained exactly how much solution has been injected into each batch. This practice has been adopted at Mt. Vernon, Ill., and found to be a very complete check upon the computations made by gaging the tanks to ascertain the total amount absorbed, the latter applying only to the whole retort charge, say 900 ties. At first a few buggy loads were found not to have absorbed enough, and they were accordingly treated a second time, but the experience thus obtained led to such sorting of ties and varying of strength of solution daily that great regularity ensued. So far as we know this practice has not been adopted at any other plant in this country.

(7) REQUIRE DAILY REPORTS OF RUNS.—ALSO YEARLY STATEMENTS.—In Germany and France automatic gages, with clock attachments, record the vacuums, the pressures and the time occupied by each. The diagrams so obtained are daily given to the party for whom the work is done. General statements are also required at the end of each season's operations, showing the amounts of chemicals on hand at the beginning, the amounts purchased, and the amounts left on hand at the end. This serves as a check on the amounts injected. These may by some be considered redundant refinements, and be omitted here, but daily reports of each run are also made in Germany, and some of the American works follow this practice.

(8) DRY THE TIES BEFORE LAYING IN THE TRACK.—This applies chiefly to the Wellhouse process, the leatheroids requiring setting and hardening before they act as seals to the outer sap cells. Drying is also necessary in plan burnettizing. From 10 to 30 days are sufficient, and may be obtained during transit or at the point of delivery for use.

(9) USE DATING NAILS AND KEEP RECORD OF TIE RENEWALS.—Special attention was called to this last recommendation by a circular, Nov. 12, 1902, issued by Mr. Geo. W. Kittredge, President of this Association. It is hoped that the importance of Mr. Kittredge's last recommendations, that "the value of an accurate record of the life of ties cannot be overestimated," will be appreciated and acted on. Material improvements have been made in the treating methods at many American plants, and more will doubtless be made as experience increases. Full records will show how these will affect the average life of the ties when laid in the track. Similar improvements have taken place in Europe. Some works were found to accomplish much better results than others, and the treating of ties has become a specialty carried on by experts.

Various methods of marking ties by systems of notching have been suggested, but after careful investigation the committee believes that such system is of questionable value. The Southern Pacific, the Santa Fe system and perhaps others indent on the ends of ties figures indicating month and year of treatment. This is done by use of a hammer, on the face of which the figures are cut, different ones for each month being necessary. This method is reported to be fairly satisfactory, though the figures are sometimes blurred by trackmen in knocking ties to line in the track.

E. B. Cushing, Engineer. M. of W., So. Pac. Co.; Robert Bell, Supt., Penn. R. R.; W. Archer, Prin. Asst. Engr., B. & O. S. W. R. R.; J. B. Berry, Chief Engr., Union Pacific R. R.; O. Chanute, Cons. Engr.; W. W. Curtis, Cons. Engr.; R. R. Hammond, Gen. Mgr., C. & E. I. R. R.; E. E. Hart, Engr., N. Y., C. & St. L. R. R.; W. W. Hayden, Asst. Engr., Y. & M. V. R. R.; C. C. Maliard, Div. Engr., So. Pac. Co., J. C. Nelson, R. M., Ala. Gt. So. R. R.; S. M. Rowe, Cons. Engr.

A CONVENTIONAL SYSTEM OF TREATING WHEEL LOADS.

By M. F. Brown,* Assoc. M. Am. Soc. C. E.

Some time since, being dissatisfied with all the conventional methods of treating locomotive wheel loads with which he was familiar, and having in mind the annual spring rush of work to be estimated, the writer began to look into the subject of conventional loading to see if some more accurate method than the equivalent uniform loadings or the excess loads with following train load had not been devised. The standpoint from which the writer was obliged to view the subject was that of a contractor's engineer, which condition precluded the adoption of any system of loadings which would result in a design of any considerably increased weight over that resulting from the use of the usually specified wheel loads, while at the same time, of course, any considerable diminution of sizes was not to be permitted.

In the Proceedings of the American Society of Civil Engineers for August, 1899, may be found a considerable number of different methods which were advocated by various engineers; the one proposed by Mr. W. L. Cowles, M. Am. Soc. C. E., seemed to give the best results, at the same time being very simple of application and not requiring any special formulas or tables for the valuation of the loadings used. This method consists, as near as the writer can determine from the somewhat meager description given, of the use of two panel loads, each equal to the maximum floor-beam concentration from the engine wheel loads, one of these panel loads being placed at the first panel point of the truss and the other at the nearest panel point under the second locomotive; the remaining panel loads being equal and of such value as to produce with the two heavy loads the same shear in the end panel as the maximum produced by the wheel loads. This series of panel loads, once obtained, was fixed in value for the particular span and panel length, and progressed on the bridge one panel at a time for all shears, covering the entire bridge for all moments.

Mr. Cowles, as an illustration of his system, figured the stresses in spans of 125 ft., 150 ft., 175 ft., 200 ft., and 300 ft., all being Pratt trusses, with 25-ft. panels. These trusses were figured (1) for the rigid system of wheel loads, (2) for Mr. Cowles' conventional method "B," above described, and (3), for three other conventional methods in common use. In the comparison between these different methods, method "B" shows up to very great advantage. The writer was, however, loath to adopt any system for general use on the strength of results obtained from only five different lengths of span, all of them of the same type of truss and all of the same panel length.

For this reason the writer, together with Mr. C. R. Perry, Assistant Engineer, Boston Bridge Works, worked out in the same way a somewhat more complete series of trusses covering a greater range of spans than did the calculations of Mr. Cowles, and also covering different types of truss and different panel lengths. These trusses were figured for: (1) Wheel loads; (2) Mr. Cowles' method, which the writer has dubbed the "Two Floor-beam Maximum" (2 Fl. Bm. Max.) method; (3) a modification of the last-named, which uses a head panel load equal to the maximum floor-beam concentration and following equal panel loads of a value which, with the head panel load will produce the same shear in the end panel as the maximum produced by the wheel loads; this series of loads progresses on the bridge a panel at a time for all shears and covers the entire bridge for all moments. This method is dubbed the "One Floor-beam Maximum" (1 Fl. Bm. Max.) method; (4) a uniform load giving the same center moment as the wheel loads; (5) a uniform load giving the same moment at the quarter point as the wheel loads; and (6) a uniform load giving the same shear in the end panel as the wheel loads. The loading used in these calculations was Cooper's E — 40, taken as being a fairly representative engine.

The writer also made figures for one or two spans using loadings which present a greater variation between the engine loads and the following train load; the results agreed closely with those of the above-mentionel series of calculations.

The results of the investigation are typified by the accompanying Table I., which gives the figures obtained for a 160-ft. double-intersection truss having eight panels of 20 ft. each. In this table the figures given for the chord members are the actual stresses in these members as calculated; for the end posts and diagonals the table gives the vertical shear, which will, of course, have to be multiplied by the secant of the angle with the vertical to give the stresses themselves. It should be noted that the results have all been obtained by the use of the slide-rule, and consequently may be somewhat in error in the last significant figure:

Similar calculations were made and tabulated for sixteen different trusses, as follows:

Span.	Kind of truss.			
90-ft.	Triangular truss, with verticals.	6	panels at	15 ft.
120-ft.	Pratt	8	" "	15 "
120-ft.	Pratt.	6	" "	20 "
120-ft.	Double intersection	8	" "	15 "
120-ft.	Double intersection	6	" "	20 "
160-ft.	Pratt	10	" "	16 "
160-ft.	Pratt	8	" "	20 "
160-ft.	Double intersection	10	" "	16 "
160-ft.	Double intersection	8	" "	20 "
180-ft.	Pratt	9	" "	20 "
200-ft.	"	10	" "	20 "
200-ft.	"	8	" "	25 "
240-ft.	"	12	" "	20 "
240-ft.	"	10	" "	24 "
300-ft.	"	12	" "	25 "
300-ft.	Subdivided panel Pratt	10	" "	30 "
		20	" "	15 "

The calculations are too voluminous to reproduce here, but they are fairly represented by the figures of Table I. The results of the entire series may be briefly summarized as follows: The use of the "Two Floor-beam Maximum" method gives results for the chords varying from the correct stresses by amounts from 6,000 lbs. (— 3.4%) for the 90-ft. span to less than 2% for the 120-ft. and longer spans, almost without exception. The shears in the web are by this method either exact or slightly in excess of the true values, the actual variation being + 4,000 or less, though the percentage is large in the counters, increasing the farther back we get. An increase in the stresses in the counters is a commendable fault, however, and the actual difference in the stresses will add little to total weight. The results for the double-intersection trusses are very close, even back to the last counter (or what corresponds to a counter). As this class of truss is especially difficult to figure by wheel loads, such close results by a conventional method are particularly gratifying. The results are somewhat closer for the 20 and 25-ft. panels than for the 15 and 16-ft. panels; as the ordinary panel is considerably closer to 20 ft. than it is to 15 ft., the results will be correspondingly close.

The results by the "One Floor-beam Maximum" method are not so close as by the "Two Floor-beam Maximum," but are very good, and are nearer than any of the uniform load methods. The method is somewhat simpler than the "Two Floor-beam Maximum," and consequently may be preferred accordingly.

Of the uniform load methods, the "Quarter-Point" method gives the closest results, though it falls down badly in the web members of the double-intersection trusses. The method is not so easy of application as either of the "Floor-beam Maximum" methods provided one has to start direct from the wheel loads without the use of a prepared table of equivalent loads, nor does it give such close results. In this method, the web would have to be figured for wheel loads, or at least some other conventional system.

As an illustration of the "Two Floor-beam Maximum" method, and the ease of obtaining the panel loads, let us take an example, say the 160-ft. truss with 20-ft. panels, given in Table I.

The criterion for maximum shear in the end panel of a truss with equal panels is that the load in the panel must equal the total load on the bridge divided by the number of panels. This would obtain with the second driver at the panel point, but not for any other loading, as:

Load in panel = 30,000 to 50,000 lbs.

Load on truss = 372,000, and $\frac{372{,}000}{8}$ = 46,500 lbs.

Shear on bridge considered as a girder:

Trn ld	$88{,}000 \times \frac{22}{160}$ = 12,100	12,100	
Eight tend'r wh'ls,	$10{,}400 \times \frac{85}{100}$ = 55,300	Or, if c. g. of two engines has been obtained	
Eight eng. drivrs	$16{,}000 \times \frac{109.5}{160}$ = 109,500	$284{,}000 \times \frac{101.6}{160}$	= 180,400
Two pilot wh'ls,	$20{,}000 \times \frac{125}{160}$ = 15,600		
Total	192,500		192,500

Subtract end stringers reaction at abutment.

$20{,}000 \times \frac{5}{70}$ = 5,000

$1{,}000 \times \frac{13}{20}$ = 6,500

192,500 − 11,500 = 181,000 = shear in end panel.

The Maximum Floor-beam Concentration from one rail for a 20-ft. panel, from Cooper's Specifications, 1901, is equal to 65,500 lbs. Taking then 65,500 as our maximum panel load, the first one at the head of the train, the second one would come three panels back. Then the value of the regular panel loads is found as follows:

$65{,}500 \times \frac{7+4}{8}$ = 90,200

Shear in end panel = 181,000

$90{,}800 \times \frac{8}{1+2+3+5+6}$ = 42,700 lbs.

which is the regular panel load following the two concentrations of 65,500 lbs. each.

The above loadings once obtained, the shears and moments may be calculated readily in a very few minutes. The calculation for obtaining the panel loads in the above case are easily made in fifteen minutes.

A BILL TO REGULATE ADVERTISING on public buildings and grounds, and prohibit advertising signs on private property without the permission of the owner of the property, has been passed by the legislature of Pennsylvania and approved by the Governor. This measure is one of the first fruits of the agitation by the American Park and Outdoor Art Association, noted editorially in our issue of Feb. 26, 1903. Further information on this topic may be obtained from the president of the association, Mr. Clinton Rogers Woodruff, North American Building, Philadelphia.

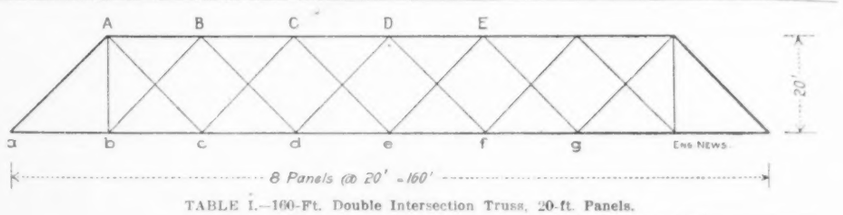

TABLE I.—160-Ft. Double Intersection Truss, 20-ft. Panels.

Member.	Wheel loads; stress	2-Floor beam maximum— Stress.	Diff.	Per cent.	1-Floor beam maximum— Stress.	Diff.	Per cent.	Equivalent uniform loads— Equal center moment— Stress.	Diff.	Per cent.	Equal ¼-point moment— Stress.	Diff.	Per cent.	Equal end shear— Stress.	Diff.	Per cent.
A—B	257	255	— 2	— 0.8	250	— 7	— 2.7	247	— 10	— 3.9	248	— 9	— 3.5	257	0	0.0
B—C	343	338	— 5	— 1.5	342	— 1	— 0.3	346	+ 3	+ 0.9	347	+ 4	+ 1.2	361	+ 18	+ 5.2
C—D	395	401	— 6	— 1.5	387	— 8	— 2.0	395	0	0.0	396	+ 1	+ 0.3	412	+ 17	+ 4.3
a—b	181	181	0	0.0	181	0	0.0	173	— 8	— 4.5	174	— 7	— 3.9	180	— 1	— 0.6
b—c	223	222	— 1	— 0.5	227	+ 4	+ 1.8	223	0	0.0	224	+ 1	+ 0.5	233	+ 10	+ 4.5
c—d	326	328	+ 2	+ 0.6	319	— 7	— 2.2	322	— 4	— 1.2	323	— 3	— 0.9	336	+ 10	+ 3.1
d—e	370	368	— 2	— 0.5	364	— 6	— 1.6	371	+ 1	+ 0.3	372	+ 2	+ 0.5	387	+ 17	+ 4.6
A—a	181	181	0	0.0	181	0	0.0	173	— 8	— 4.5	174	— 7	— 3.9	180	— 1	— 0.6
A—b	109	107	— 2	— 1.8	112	+ 3	+ 2.7	99	— 10	— 9.0	100	— 9	— 8.0	103	— 6	— 5.5
A—c	84	84	0	0.0	88	+ 4	+ 4.8	78	— 6	— 7.0	78	— 6	— 7.0	81	— 3	— 3.6
B—b & B—d	61	60	— 1	— 1.6	62	+ 1	+ 1.6	53	— 8	— 13.0	53	— 8	— 13.0	55	— 6	— 10.0
C—c & C—e	48	47	— 1	— 2.0	47	— 1	— 2.0	40	— 8	— 17.0	40	— 8	— 17.0	42	— 6	— 12.0
D—d & D—f	28	28	0	0.0	28	0	0.0	22	— 6	— 21.0	22	— 6	— 21.0	23	— 5	— 18.0
E—e & E—g	19	19	0	0.0	19	0	0.0	15	— 3	— 16.0	16	— 3	— 16.0	17	— 2	— 11.0

*Chief Engineer Boston Bridge Works, Boston, Mass.

RECENT MINING AND MILLING COSTS AND METHODS ON THE MOTHER LODE, CALIFORNIA.

By Frank Langford,* M. Am. Inst. M. E.

PLANT.

The Melones Mine, Calaveras County, Cal., is developed by a tunnel across country 4,000 ft., connecting with a rise 225 ft. to a level which connects, 550 ft. with the main shaft or rise 625 ft. to surface in the lode.

The mill, 850 ft. from portal of adit, is equipped with crushers, 60 1,000-lb. stamps, feeders, plates, tables of the Wilfley type, and vanners. It is driven by water power direct, by shafting and belts. The water is brought by flume and penstock four miles from a dam in the Stanislaus River, to the wheel under mill, under 64-ft. head.

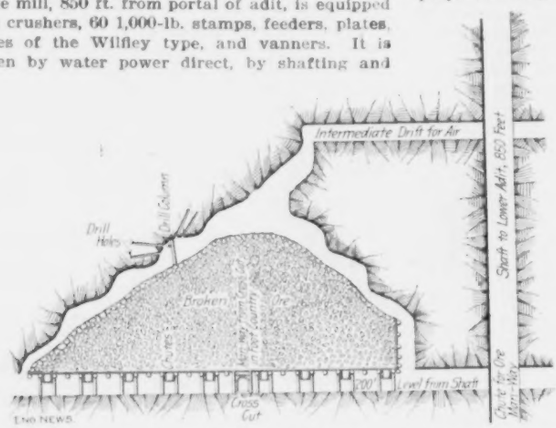

FIG. 1. MELONES MINE STOPE AND CONNECTIONS ALONG HANGING WALL.

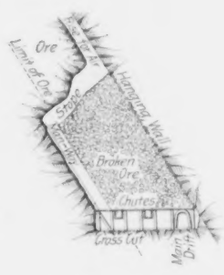

Fig. 2. Section Through Wide Part of Lode, Melones Mine, Cal.

Air compressors for mine power and generator for electric haulage are located at mill, and are driven by the one unit of power with the mill. The air is piped overground to collar of mine shaft 6,000 ft. to a battery of old boilers for receivers, with provision for reheating before delivery to the drills, of which there were in operation five 3½-in. and 2 2¼-in. The large drills are used in the larger stopes and drifts, and the smaller drills in the lesser openings; and, as evidence that the mine will not be burdened with the "hobby" that some particular machine is "the only one," it may be said that electric drills will probably be used as an economy in power for some special work, and that an air drill is being designed to weigh not over 20 lbs. to be run without mounting for blockholing large pieces of ore in the stopes.

No stoping has been done below 200 ft. from collar of shaft, and the shaft below 200-ft. level is used as a chute for the ore, without stop or timber, to the first pocket, 425 ft., nearly vertical. There is some crushing of the ore in this fall!

The accompanying sketches, Figs. 1 and 2, will serve to illustrate the method of attack underground. The ore is slate, quartz and hard greenstone, with the values in free gold and in gold-bearing iron sulphide. The lode dips about 70° from horizontal, and has generally a definite and firm hanging wall, but no well-defined foot wall. The stopes vary from 4 to 40 ft. in width.

Drifts are driven out from the shaft along the hanging wall and timbered for stoping, with sets 5 ft. in width by 6½ ft. high in the clear (posts 12 × 12-in. and caps 14 × 12-in.), or with stulls, where the rock is perfectly solid; spaced 5 ft. 4 ins. centers, to receive without waste 16 ft. lagging of 3-in. plank. Loading chutes are placed along the foot side of drift 16 ft. apart. They are made 3 ft. wide to prevent choking with large pieces of ore.

In the wider sections of the lode (30 ft. or more) crosscuts are driven out from the main drifts, through the ore, and are timbered for stoping and loading. Drilling is then commenced over the timbers at the junctions of crosscuts with main drifts. The stope is opened in opposite directions along the hanging wall, and out over the crosscut simultaneously. The foot of the stope is carried out from the hanging on a slope of 45° upward, and similarly outward from both sides of the crosscut. It is advanced upward more rapidly along the hanging wall. The back of overhanging rock is arched outward and downward from the hanging wall. The stopes are advanced in the wider sections of the lode ahead of the narrower, forming arches along the hanging wall.

Manways and passes for air, pipe, temporary props and tools used in the stopes are carried up against the hanging wall in the narrower sections and adjacent to any poorer sections that may be left as supporting ribs or shaft pillars; also from the ends of the crosscuts in the foot country.

Broken ore is carried into the stopes filling them close to the backs, for the miners to stand on and to support the hanging wall. When these upper stopes have been carried up to, or near the surface, and completed, the ore filling will be drawn out and sent to the mill. The stope will be partially filled by blasting waste from the upper portions on top of the descending ore column, which will follow the ore down and form a cushion over the level for the hanging wall to cave to. Some waste will be mixed with the last ore drawn from the stope; but since the rock adjacent to the lode carries some values it is ideal for filling.

As the mining proceeds the surplus ore not required to fill the stopes is drawn through the loading chutes into 1-ton cars and trammed to shaft, dropped 425 ft. to a pocket, from which it is drawn into 1¼-ton side dump-cars, six in train, and hauled 550 ft., at the rate of five trips per hour by one horse with two men. Here it is dumped again and drops 225 ft. vertically to a pocket on the lower adit level, where it is drawn into 8-ton bottom dump-cars, four in train, and hauled by electric locomotive 4,700 ft. to outside mill bin; 400 tons have been handled by this train in 10 hours by two men. With six cars in a train, and the ore running freely at the loading chutes, 600 tons could be handled in 10 hours by two men.

From the outside bin the ore is drawn into a 1-ton car, trammed 150 ft. and dumped direct to Gates crusher, without a feeder, at the rate of 150 tons in 10 hours, by one carman. The crushed ore is distributed with a car over the 1,000-ton battery bin, from which it runs by gravity to 12 automatic feeders, to 60 1,000-lb. stamps. The pulp passes from batteries over the copper plates, and to 12 concentrating tables attended by one man. Tailings from the tables go to 24 Vanners attended by one man; tailings from the Vanners going to waste sluice and passing on the way an automatic sampler, which "never sleeps."

In fact it may be believed that no individual unit in the operation sleeps very soundly "on shift," when it is considered that each man daily accomplishes work equivalent to mining nearly five tons of ore, transferring it five times and attending the machinery in its reduction; and this on a comparatively small tonnage, which is one of the most important factors in mine costs. The next most important factor is low-grade ore as an incentive to economy.

COSTS.—The accompanying table of working costs covers a period of 29 days of actual operation in the month of **November**, 1902, during which time 8,500 tons were mined and 6,500 tons were milled.

COST OF MINING.

Items.	Cts. per ton.	
Drilling for blasting	12.0	
Block holing and spawling broken rock in stopes to pass chutes	6.6	
Shoveling and tramming to shaft	8.0	
Timbering	2.5	
Foremen, blacksmith and helpers	6.0	
Total labor of mining		34.5
Explosives	5.6	
Timber	1.2	
Candles, drill repairs and miscellaneous	1.8	
Proportion of power for air drills, labor	1.7	
Proportion of power for air drills, supplies	0.2	
Total supplies and power		9.9

COST OF TRANSPORTATION.

(One mile underground on two levels.)

Drivers, motormen and helpers	6.0	
Oil, lights, horse feed and miscellaneous	1.0	
Electric power, labor	0.8	
Electric power supplies	0.1	
Total ore transportation		7.9

COST OF MILLING AND CONCENTRATION.

Labor	15.3	
Supplies	3.0	
Power, labor	2.5	
Power, supplies	0.3	
Total, milling and concentration		24.1
Grand total		76.4

SUMMARY.

Total labor of mining	34.5
" supplies for mining	9.9
" ore transportation	7.9
" milling and concentration	24.1
Grand total	76.4

Of the 8,500 tons of ore mined, 4,750 tons were from overhead stopes by air drills; 750 tons from development drifts by air drills; 1,250 tons from open cut, 40 ft. depth, by air drills; 1,750 tons from open cut, surface, by churn drills.

Feet of holes drilled per ton of ore:	
Overhand stopes	⅘ ft.
Drifts	2 "
Open cut	⅓ "
Surface, soft ore	⅓ "
Depth of holes in stopes	8 "
Depth of holes in drifts	5 "
No. 2 40% dynamite used per foot of hole	⅝-lb.
No. of days in actual operation for month	29
Daily average tonnage mined	293 tons
Daily average tonnage milled	224 "
Greatest output for one day	400 "
Average wage rate	$3.00

Comparative costs for direct labor and explosives in getting the ore in the different stopes:

	Cts. per ton.
Overhand stopes, hard ore, by air drills	30.0
Drifts, hard ore, by air drills	76.6
Open cut, hard ore, by air drills	26.8
Surface, soft ore, by churn drills	18.0

A FAST RUN on the New York Central by the Empire State express is described in a circular issued by General Passenger Agent Daniels. The run was made on Jan. 1, last, by the Empire State Express, which left Syracuse 31 minutes late and ran to Rochester, 80 miles, at an average speed of 67.60 miles per hour. Mr. Daniels gives the following figures from the train dispatcher's official sheet:

Stations.	Miles.	Mins.	Average miles per hour.
Syracuse to Syracuse Junc. tower	2.16	6	21.60
Syracuse Junction to Jordan	13.97	11	76.20
Jordan to Port Byron tower	7.74	7	66.34
Port Byron to Savannah	7.05	4	105.75
Savannah to Clyde	6.09	5	73.08
Clyde to Lyons	7.07	7	60.60
Lyons to Palmyra	12.93	11	70.50
Palmyra to Macedon	7.29	4	109.35
Macedon to Rochester	15.47	16	58.01

It is unfortunate that the record of the time of passage of stations is only given in even minutes, since this throws doubt on the accuracy of the two speed records in excess of 100 miles per hour. We reported in our issue of Feb. 5 another run of this same train, made on Jan. 29, in which the same speed was claimed for the distance from Palmyra to Macedon. It is to be regretted that automatic speed recorders on the locomotive and stop watches on the train were not used to check these remarkable records.

SKYSCRAPING BUILDINGS now under construction in New York city number 64, according to a summary in the New York "Tribune" of March 22. Of these, 14 are located in or near the downtown financial district. The buildings are classified by their height in stories as follows:

No. of stories	9	10	11	12	13	14	16
No. of buildings	4	12	7	24	1	2	5
No. of stories		17	18	20	22	24	25
No. of buildings		2	2	3	2	1	1

*Superintendent Melones Mining Co., Robinsons, Cal.